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New York Meeting of the American Electrochemical Society.

It has become the custom of the American Electrochemical Society to hold every autumn a short meeting in New York City. This year's meeting, the program of which will be found on another page of this issue, will be held on Friday and Saturday, Oct. 30 and 31. The College of the City of New York in its magnificent new home and the ever hospitable Chemists' Club will be the hosts of the Society. That the New York Committee endeavors to make the social functions as enjoyable as ever, goes without saying. A great attraction will prove the excursion on Saturday afternoon to the Balbach Smelting & Refining Works in Newark, as this is the birth-place not only of the Balbach electrolytic process for parting gold and silver, but of electrolytic copper refining in the United States. The process was worked out by Messrs. Edward Balbach, Sr. and Jr., and by Mr. F. A. Thum, and the commercial plant started in 1883, just 25 years ago. It is fitting that at this time the American Electrochemical Society should pay its tribute to the pioneers of copper refining in America. The program of the papers to be read and discussed is also quite attractive. In a general way the morning session of Friday will be devoted to papers of a more scientific character, the afternoon session to a symposium of papers on corrosion of iron and steel and preventives, while a feature of the morning session of Saturday will be a discussion of possible cooperation between central station men and electrochemists as to the utilization of the power at times of low load for electrochemical work. This is an excellent subject and it comes at the right time, since we are now apparently on the eve of resumption of business. We trust that the coming convention will help to inspire in all who attend it that professional esprit de corps which will be needed more than ever, when business activity will again be in full blast, with sharp, but friendly competition.

Finished Steel Products by Electrolysis.

Not so many years ago—say, seven or six—any suggestion on the use of the electric furnace in iron and steel metallurgy was declared to be positively absurd. The stock argument was the proof that on the basis of thermochemical data and with the present price of electrical energy, reduction of iron ore to pig iron in the electric furnace could not possibly compete with the blast furnace. This was a simple and easy enough argument. To speak or to think of the possibilities of the electric furnace for steel refining was too complicated a matter to argue about. But it was right at this point, as the point of least commercial resistance, that the industrial development set in; and it is a matter of some satisfaction to us that the development has proceeded exactly along the lines predicted by us ever since this journal began to make a specialty of this subject early in 1903. The list of electric steel furnaces in Europe alone, published

elsewhere in this issue, proves the absurdity of the arguments of the former critics of the electric steel furnace. In view of this, people should be cautious in speaking rashly of the impossibility of electrolytic processes in iron and steel metallurgy. The problem of reduction of pig iron from iron ore by an electrolytic process (analogous to the reduction of aluminium from alumina, but perhaps with an aqueous solution) seems, of course, hopeless. Not only from the energy standpoint, but because a simple estimate of the reduction plant required shows its first cost to be absolutely prohibitive—if pig iron is to be the final product of electrolysis.

The process appears in an entirely different light if it should become commercially practical to make steel tubes, sheets, wire from impure iron or iron ore in one or two operations, so as to avoid the processes of melting, rolling, etc., as described in the article of Mr. Cowper-Coles in our present issue. That Mr. Cowper-Coles can produce tubes, sheet, and wire by electrolysis, there is no doubt. The only question is that of cost, and this cannot be settled except by practice. Mr. Edison has been making for years the seamless steel containers for his nickel-iron battery by electrolytic deposition upon a mould. This product has been excellent, and in this case the cost of the electrolytic process may be called low, as the cost of producing this high-grade product by other methods would be much higher. Clearly, the prospects of the electrolytic process are best for the manufacture of special articles like bi-metallic tubing and plates, etc. But it seems safe to say that it will always be necessary to start with a relatively pure anode material in order not to foul the solution. This is the fundamental requirement of any electrolytic process that shall work in practice. The essential new feature of Mr. Cowper-Coles' process is the electrolyte, which is sulpho-cresylic acid. Another line along which electrolytic processes may find useful employment in steel metallurgy in future, is the refining of iron, as by the process of Burgess. The refined iron which is almost chemically pure and contains absolutely no carbon would be a highly valuable raw material for making special ferro-alloys. Here is still an almost unlimited field for research. Iron and steel metallurgy has always been limited to the study of iron-carbon alloys. To determine the possibilities of iron alloys containing no carbon, is a subject that deserves greatest attention.

Estimating the Cost of Experimental Work.

It is always hard to make an accurate engineering estimate of the probable cost of any new installation. The reason for this is that conditions always alter cases, and new and unexpected unfavorable factors are sure to arise, and by the perversity of things usually tend to increase the cost of the work. For instance, in building the concrete foundations of a concentrating mill in the West, it had been assumed that there was plenty of sand in a neighboring dry water-course. However, in the meantime a precipitous rain came and wasted the nearby sand away. Accordingly, it was necessary to haul sand from the valley below with four-horse teams up to the site of the new mill. This added 50 per cent to the cost of the concrete work. So it can be laid down as an axiom that any new plant will exceed the estimated cost unless liberal allowances are made for unexpected expenses.

Naturally, it is much harder to estimate the cost of experimental work, because here the question dealt in is largely expressed in the terms of the unexpected. The experiment is to find out not the expected, but the unexpected. If in a proper estimate of the cost of work along old and well tried methods it is always necessary to include a large item for contingent expenses, how much larger must that be when the field is a new one. While logical guesses can be made, yet it is advisable, if possible, to follow some few rules which appear to govern these guesses. The following suggestion has been given us by an engineer who has spent much time and attention in experimental work. His directions are first to draw up the plans on paper exactly similar to the plans for any plant, allowing, we will say, 4½ cents per pound for the cast iron erected, 6 cents per pound for the steel such as tie-rods and brick-stoves erected, fire-brick at cost plus \$15 per thousand for laying. He then adds what he considers a fair amount for contingent expenses and 20 per cent for the unexpected, just as he would if he were estimating the cost of an old proposition, such as a copper smelter.

Footing up the totals, he arrives at a figure which would be accurate were the plant a small one, designed for a well-established process like copper-matting. His next step is to multiply this figure by what he terms the "factor of commercial safety for experimental work." This will vary from two and one-half to five, according to the degree of uncertainty. By the use of this method he finds that he usually comes very close to the estimated expense before reaching a final decision pro or con, but only if he uses economy and foresight in his expenditures. But if eternal experimenting is the price of progress, the price should be known as accurately as possible to the weak and poor human. Things are always uncertain in money matters, but it is necessary to introduce some certainty and conservatism, for the foxy and wary capitalist has always the terror of the infant for the dark unknown.

The Evolution of Induction Furnace Design for Steel Refining.

The description, in our present issue, of the Roechling-Rodenhauser three-phase induction furnace emphasizes the peculiar development of induction furnace design leading from the original pure induction type of Colby and Kjellin to the combined induction and electrode type of Roechling and Rodenhauser for single-phase current and finally to the modification of the latter type for three-phase currents. Electrical, mechanical, and metallurgical considerations have determined this evolution. From an electrical viewpoint, the powerfactor has been the chief consideration. The pure induction furnace is essentially a transformer with a fused secondary; and the high temperature of the fused charge which represents the secondary necessitates careful heat insulation from the primary and from the magnetic iron core. On this account not all the lines of magnetic flux encircle both the primary and secondary. Some lines of flux will pass only around one of them and close their path through the available space between primary and secondary. That means, we have a considerable magnetic stray flux; we have self-induction in the two circuits instead of mutual induction. As a result we have a low powerfactor, i. e., a low

ratio of effective watts to volt-amperes. Since the powerfactor is occasionally looked upon by electrochemists and electro-metallurgists as something mysterious and since the question has been asked why it would be such a dreadful thing to have a low powerfactor, a brief explanation of its effects may be given here.

* * *

The power in watts equals directly the product of volts and amperes in every instantaneous moment with single-phase current as well as with direct current. But with our ordinary measuring instruments we do not measure instantaneous values, but effective values, i. e., mean values. Any self-inductance will cause a phase difference between e.m.f. and current, and as a result the product of the instantaneous values of e.m.f. and current will be positive for a part of a period and negative for the balance of the period. In other words, the transport of energy over the single-phase line fluctuates. There is a surging of power, energy being transported in part of one period over the line in one direction and in the balance of the period in the other direction. Only the difference between the two amounts of energy is usefully consumed at the receiving end. But the generators have to supply and the line wires have to carry the total volt-amperes. This will be worse the greater the phase difference, and as the powerfactor may be defined as the cosine of the phase-difference, it is clear that a low powerfactor means a large phase difference and consequently a large surging of power and a comparatively small amount of useful power. The effective watts are no longer equal to the product of effective volts and effective amperes. The ratio of the two is the powerfactor. In other words, the powerfactor is the ratio of the effective power to the ideal amount of power which we would get if there was no phase difference, no surging of power. Hence a low powerfactor means the necessity of using large generators and thick wires. To be more specific, a 50-per-cent powerfactor means the necessity of using conductors of double size, to get the same loss in watts; and it means the necessity of using generators of double capacity, to produce the same useful output. But even so the voltage regulation of the line and of the generators will be poor. It is clear that power companies will object to the use of furnaces having a low powerfactor. On the other hand, if a steel plant generates its own electric power, the use of furnaces with a low powerfactor necessitates an undue increase of the generating capacity of the powerhouse, resulting in increased capital investment and increased cost of operation.

* * *

To reduce the power factor has, therefore, been properly the aim of designers of induction furnaces. One possibility of accomplishing this is to reduce the frequency of the alternating current. But it was soon found that such an unusually low frequency would be necessary for large furnaces as to require special expensive generators. The problem had, therefore, merely been shifted, not solved, as far as large furnaces were required. For smaller furnaces, such as are used for brass, crucible steel, and alloys, the pure induction furnace is quite satisfactory. But for large furnaces the designer was between the devil of a special expensive low-frequency generating plant and the deep sea of a low powerfactor. The solution was to cut the Gordian knot by dropping the pure induction principle and adopting electrodes. The designers of the Roechling-

Rodenhauser furnace do not like to hear their "pole-plates" called electrodes, and the arrangement of their pole-plates and the use of a "conductor of the second class" really means a new departure in electrode construction. Further, they contain no carbon, nor is any regulating mechanism required for these electrodes. The chief point is that on the combination-furnace principle it is now possible to build large furnaces with a satisfactory powerfactor, which can be operated at ordinary commercial frequencies. In this respect the modified induction furnace is no longer at a disadvantage in comparison with other types of electric furnaces.

* * *

The passing of the single-phase furnace and the arrival of the three-phase furnace is interesting in another respect. The three-phase furnace is not entirely new even with steel furnaces. The first Hérault furnace at the Noble plant in California was already built as a three-phase furnace for the reason that the distribution system was three-phase. The same system is used in many steam plants. But even if it is necessary to build a new generating plant, the plant will be cheaper for three-phase furnaces than for single-phase furnaces. As prices of generators now go, it is practically true to say that a 1000-kw single-phase generator costs as much as a three-phase generator which will carry 1000 kw of single-phase load, when only two of its terminals are used. Therefore, if the latter is operated as a three-phase generator, it will furnish power for a correspondingly larger furnace. The cost of three-phase generating plant per kw of furnace capacity is therefore less than the cost of single-phase generating plant.

* * *

However, it would be a narrow viewpoint to look only at the electrical features which have prompted this evolution. Strictly mechanical reasons had undoubtedly much to do with the change from the pure induction furnace to the combined induction and electrode furnace. The narrow, ring-formed channel, containing the charge of the pure induction furnace, offers some difficulties in charging, tapping, cleaning, etc. For relatively small charges, for brass melting, for crucible steel and for alloys, things can be arranged satisfactorily. But for large capacities, as in steel making and refining, the construction of a ring-channel with large volume becomes unwieldy. The large hearth of the new combination furnace solves this difficulty. It also solves nicely some metallurgical problems. If steel is to be refined by means of a very hot slag, it will be very difficult or impossible to get the slag hot enough in a pure induction furnace, because the induced currents will prefer the path of least resistance, i. e., the metal bath. By the special construction of the Roechling-Rodenhauser furnace the current from the pole-plates is forced through the slag. Further, the rotary magnetic field of the three-phase furnace furnishes an excellent automatic circulation of the bath. Finally in the latest designs the object has been to imitate as closely as possible best open-hearth practice. But, after all, one is forced to ask: Is this really the end of this evolution? Why not give up the induction principle altogether, at least, for large capacities? Or, if not altogether, why not connect at least the three pole-plates directly with the transformer or generator, instead of including them in a second secondary circuit? Is not the present design, after all, only a temporary compromise? *Qui vivra verra.*

New York Meeting of American Electrochemical Society.

The autumn meeting will be held, in accordance with custom, in New York City. The dates are Oct. 30 and 31, Friday and Saturday. The final program is as follows:

The sessions of Oct. 30 will be held at the Chemistry Building, College of the City of New York, in the Doremus Lecture Hall on the second floor. The college buildings are located on Amsterdam Avenue, 138th Street to 140th Street. (Take Broadway train on subway to 137th Street Station, or Ninth Avenue Elevated to 141st Street Station.)

The session of Oct. 31 will be held at the Chemists' Club, 108 West Fifty-fifth Street, New York City. (The Central Park elevated trains on Sixth Avenue to Fiftieth Street, or subway to Fiftieth Street, are the nearest rapid transit connections.)

The headquarters for registering and information will be opened on Thursday evening at the hotel quarters, Hotel Cumberland, Fifty-fourth Street and Broadway. On Friday morning and afternoon the office for registering and information will be at the College of the City of New York, Chemistry Building (enter from plaza, and register in Wolcott Gibbs library at right entrance to the building). Telegraph and telephone arrangements will be provided. Calls for members may be sent to 1280 Audubon, Department of Chemistry or to Prof. Baskerville's office. On Saturday, Oct. 31, the offices are at the Chemists' Club, the telephone connection being 281 Columbus.

Badges will be given at the time of registration to all members, and to applicants who have deposited their initiation fee. Special badges will be provided for guests, including ladies, who must be introduced by a member and sign the registration book.

As already stated, the hotel headquarters are at the Hotel Cumberland, Fifty-fourth Street and Broadway, two blocks west and one block south of the Chemists' Club.

On Thursday evening, Oct. 29, a meeting of the board of directors will be held in the Chemists' Club, in the library, second floor.

The convention proper begins on Friday, Oct. 30, in the Doremus Lecture Theater, College City of New York, at 9 a. m. Prof. Baskerville, director of the laboratory, will introduce President J. H. Finley, who will welcome the society.

The following papers will then be read and discussed:

- (1) The use of a mercury cathode in the determination of metals. A. Harold Porter and Francis C. Frary.
- (2) The passivity of nickel and iron. E. P. Schoch.
- (3) Equilibria in standard cells. G. A. Hulett.
- (4) Chemical energy. J. E. Mills.
- (5) The formation of nitric acid from air by means of low-voltage direct current. G. W. Morden.

At 12:30 p. m. luncheon will be taken by invitation of the staff of the Department of Chemistry of the College of the City of New York, in Alumni Hall, main building. Ladies are invited.

A 20-minute organ recital, complimentary to the society, will be given at 1:40 p. m. by Prof. Samuel A. Baldwin, head of the department of music, in the Great Hall, second floor, main building.

At 2 p. m. the second session, devoted to the reading and discussion of papers, will be held in the Doremus Lecture Theater.

- (6) Electrolytic corrosion of the bottom of oil tanks. A. A. Knudson.
- (7) The corrosion of underground structures. Albert F. Ganz.
- (8) The function of oxygen in the corrosion of metals. W. H. Walker.
- (9) The theory of electrolytic paints. W. D. Bancroft.
- (10) Simple methods for the prevention of electrolytic corrosion. Maximilian Toch.

In the evening, at 7:30 p. m., an informal subscription dinner will be held at Reisenweber's, Columbus Circle, Fifty-eight

Street and Eighth Avenue, New York City. Ladies are especially invited to attend.

The third professional session will be held on Saturday, Oct. 31, at the Chemists' Club, 108 West Fifty-fifth Street, when the following papers will be read and discussed:

- (11) The Lash steel process and the electric furnace. F. A. J. Fitzgerald.
- (12) Utilization of power stations for electrochemical and electrothermal processes during periods of low load. E. A. Sperry.
- (13) Electrochemical loads and the central station. John Meyer.
- (14) Correct methods of measuring stray currents. Clayton H. Sharp.
- (15) The latent heat of vaporization of zinc. W. McA. Johnson.
- (16) Heat losses of furnaces through walls. Carl Hering.

Luncheon will be taken at 1 p. m. at Hotel Cumberland, Fifty-fourth Street and Broadway. Ladies are invited.

At shortly before 2 p. m. the party will leave Hotel Cumberland for an excursion to the Balbach Smelting & Refining Works, in Newark, N. J., where the processes of smelting and refining of copper, lead, silver and gold may be seen. An illustrated description of this plant, which is the pioneer copper refinery in the United States, may be found in our Vol. II, page 303.

In the evening a "smoker" will be tendered to the American Electrochemical Society by special invitation of the Chemists' Club, in the assembly room of the club, 108 West Fifty-fifth Street.

The Iron and Steel Market.

October has been a very quiet month marketwise, doubtless on account of the pendency of the national election. Production has been fairly well maintained and has lost little, if any, from the September rate. There has not been the spurt in tonnage output which usually occurs in October on account of weather conditions being particularly favorable for furnace and mill operations.

It is improbable that there will be much further gain in production during the remainder of the year. Pig iron production gained rapidly and steadily in July, August and September. Official statistics are available for production during the first half of the year, while unofficial monthly statistics have been gathered of coke and anthracite pig iron production. If the production in the second half should be the same as in the first half the year's total would be 13,836,000 tons. If the fourth quarter output should be the same as in the third quarter the total would be 15,042,000 tons. If the rate of September should be maintained through the fourth quarter the year's total would be 15,400,000 tons. The safest estimate would probably be 15,500,000 tons, with a probable error of less than a quarter million tons in either direction.

Production of rails, sheets and tin plates fell off in October as compared with September. On account of the season rails promise a further decrease, while sheet and tin plate production is likely to increase. Production of plates and merchant bars may increase, but it is not probable that shapes, wire products and tubular goods will be able to do more than hold their own.

ORE AND BLAST FURNACE DEVELOPMENTS.

During the month the interesting announcement was made that M. A. Hanna & Co., the large Lake Superior ore producers, would build two merchant blast furnaces at Buffalo, to be ready for operation early in 1910. The firm has a 10-year lease on three smaller furnaces at Buffalo, which lease expires two years hence and will not be renewed. A decision at this time to build new merchant furnaces, when almost half the merchant furnace capacity of the country is idle, may seem somewhat startling, but it is exactly in line with current developments. The merchant furnace production of the Central West

was formerly almost wholly in the hands of interests which bought their ore year by year from the merchant Lake Superior ore producers, at the season price. In recent years Lake Superior ore properties have come to be tightly held and, especially since the Hill lease to the steel corporation, it is difficult to acquire favorable leaseholds.

A number of merchant blast furnaces have been built by ore interests. For months after the October panic the merchant furnaces endeavored to peg the pig iron market, but without avail, while the ore producers have practically maintained their market, making a reduction of only 50 cents a ton for this season.

The pig iron market has gotten down to the bare cost of production to a furnace which must buy its ore at the season price. There is an excellent profit in the ore, and practically none in the pig iron. While there is evidently a surplus in furnace capacity as a whole, the capacity of merchant furnaces controlled by ore interests is far below the possible minimum demand.

The prospects are quite clear that Lake Superior ore prices will be maintained fairly well, but to be certain of disposing of ore the producers must convert it into pig iron themselves. That is the meaning of M. A. Hanna & Co.'s decision to build two blast furnaces. Corrigan, McKinney & Co., another large merchant ore interest, have plans to build a twin furnace to their present Josephine, which will give them four furnaces, two Josephine, Scottdale and Genesee.

PIG IRON.

The Pittsburgh Steel Company has covered a portion of its pig iron requirements for the next five years. It has recently completed a basic open-hearth steel plant of eight 60-ton furnaces, as an adjunct to its wire plant at Monessen, Pa., making the first steel at the beginning of August last. Occasional purchases of prompt pig iron have been made, the last being made the latter part of October, 10,000 tons from the Struthers Furnace Company at \$14, furnace, delivery 500 tons daily. About the same time a contract was concluded with the Penn Iron & Coal Company, an interest of M. A. Hanna & Co. operating a furnace at Canal Dover, Ohio, for 6000 tons of basic pig iron a month for five years commencing Nov. 1. The price is 7 per cent advance over the actual cost of production, but in no case is to exceed \$17. What the actual price will be cannot be stated, as certain terms going to make up the actual cost of production are not disclosed, in particular the cost of the ore, as the furnace company would not necessarily pay the season-to-season price to M. A. Hanna & Company. The Allegheny Steel Company bought 5000 tons of basic pig iron, delivery over the balance of the year, at about \$14, furnace.

Sales of Bessemer have been very light. The Bessemer average for September was \$15, valley, but the market is weak at that price for early delivery. Foundry iron has sold at \$15.25, delivered Pittsburgh, and forge at \$14.50. We quote the valley market for early delivery at \$14 for basic, \$14.25 to \$14.50 for malleable, \$15 for Bessemer, and \$14.35 to \$14.50 for No. 2 foundry. For delivery next year these prices could not be done, producers asking 25 to 50 cents advance.

BILLETS AND SHEET BARS.

The market has been very quiet, enlivened only by some purchases of forging billets in the Chicago district and the making of a contract between the Inland Steel Company, Chicago, and the Railway Steel Spring Company, for about 25,000 tons of rolling and forging billets, deliveries running well into next year. The market remains at \$25, Pittsburgh, for billets, and \$27, Pittsburgh, for sheet bars, half the freight being conceded when it is from \$1 to \$3 a ton.

FINISHED MATERIALS.

There is some shading in plates, sheets, tin plates and possibly also in structural shapes. In some of these lines there has been very quiet shading for two or three months, while concessions are now given more openly. While they do not cover all transactions in any of the commodities they are rather wide-

spread. In the case of structural material concessions are believed to be given only to fabricating interests in the case of some large structural contracts and to amount to about \$2 a ton. Plates are shaded quite generally as to some sizes by \$1 to \$2 a ton. Light rails are being shaded \$1 to \$2 from the official price of \$25, but this has been the rule for months. Black sheets are sometimes shaded a dollar a ton, and galvanized sheets \$2 a ton, while tin plates are shaded sometimes by 5 cents a box or more.

It appears that the large interests have been averse to taking open cognizance of these irregularities by official reductions in the recognized prices, perhaps wishing to avoid attracting public attention just before the election, or perhaps in the hope that the market would firm up after that event. At any rate, if the irregularities do not disappear after the election it is probable that some formal reductions will be made before the turn of the year.

Official prices, which, as noted, are not always observed in the case of some products, remain as follows, Pittsburgh:

Standard rails, \$28.

Light rails, \$25.

Plates, 1.60 cent for tank quality.

Shapes, 1.60 cent for beams and channels, 15-in. and under, angles and tees.

Steel bars, 1.40 cent; iron bars, 1.35 cent to 1.40 cent; Chicago, 1.50 cent.

Plain wire, 1.80 cent; wire nails, \$1.95.

Sheets, 2.45 cents, net, for black; 3.50 cents, net, for galvanized, 28 gage.

Tin plates, \$3.65, net, for 100-lb. cokes.

The Aluminium Industry in Europe.

As mentioned in a recent issue of the *London Electrical Review*, the conditions in the aluminium industry have become less satisfactory to European producers in the past year or two in consequence of the increase in competition and the fall in prices, although the latter circumstance has naturally been of advantage to consumers.

The *Neue Züricher Zeitung* now announces that the existing community of interests (the international convention) will be abolished at an early date with the object of offering keener rivalry to the new competitors. It may be remembered that a firm association of all the then existing aluminium producers was formed in November, 1901, but as the objects of the convention have now been crossed by outsiders, it is proposed to abolish the agreement. While going to press, we hear that this had been formally done on October 1. The price difference in London between copper and aluminum is now slight; the London price of electrolytic copper on October 9 was £64 to £65, aluminum £70 to £75 per ton.

CORRESPONDENCE.

Electrolytic Production of Metal Sheets.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—My attention has been drawn to Mr. T. A. Edison's Patents Nos. 880,484 and 879,859, dated Feb. 25, 1908, for "Improvements in the Manufacture of Very Thin Sheet Metal." Since the method is very similar to my Patent No. 20,073 of 1895, I think an abstract from my Patent No. 20,073 of 1895 will be of interest.

"The object of my invention is to provide means for obtaining metal in the form of sheets or strips or other forms, by electro-deposition where it is required that the metal sheet or other form of metal to be obtained, shall be entirely made by electro-deposition, as distinguished from an article consisting of a permanent basis, or backing, covered with an adherent coating of metal effected by electro-deposition.

"It is necessary in producing sheets, or other metal forms,

consisting entirely of electro-deposited metals, to provide a cathode, or base, upon which the metal is deposited but from which the deposited metal can be afterwards readily removed.

"It has hitherto been necessary to provide a cathode for this purpose which is covered by a greasy or fatty matter, such, for example, as wax dissolved in benzene, but it has been found in practice that it is impossible to ensure such a coating as shall be so perfect as to prevent the adherence of the deposited metal to the cathode in places, which, however minute, will prevent the subsequent removal from the cathode of the deposited metal in a perfect form.

"I have, by trial and experiment, found that a large percentage of aluminium, or an alloy, or compound containing a large percentage of aluminium, will receive an electro-deposition of metal, and that the metal so deposited can afterwards be readily separated from the said cathode; for example, I may remove it by rubbing it therefrom or by stripping it in the form of sheets. I prefer the former plan for the removal of deposited gold. The non-adherence of the deposited metal is owing, I believe, to the formation of a thin and even loose coating of oxide on the described cathode, which whilst not interfering with the electro-deposition of the metal thereon, prevents such adherence of the deposited metal to the cathode as will interfere with the removal, in perfect form, of the deposited metal from the cathode. If an aluminium alloy be used I find that, to give good results, the amount of aluminium should not be less than about 50 per cent of the alloy. The invention can be applied to the deposition of various metals such, for example, as gold, zinc and iron. The cathodes may be made of any suitable form such as plates, or continuous bands traversed through the electrolyte or of drums revolving therein."

LONDON, ENGLAND.

SHERARD COWPER-COLES.

Cost of Water Power in Norway.

To the Editor of *Electrochemical and Metallurgical Industry*:

SIR:—I have read with great interest the letter of Mr. F. A. J. FitzGerald on page 353 of your September issue. From what he says on the cost of electric power in electrometallurgy of iron and steel, I note that he prefers to base estimates of cost on a rate of \$15 per hp-year at the electric furnace terminals under American conditions.

If we had to figure with such a price in Norway the prospects for the future industrial development of the electrometallurgy of

Bergen and Mendal, is between 6.6 and 7.3° C. It will further be seen that not in any month of the year the mean temperature drops below the freezing point of water. This corresponds nearly to the climate of Milan, Italy. In the valley of Hardanger, which is rightly called the orchard of Norway, even tobacco culture is successfully carried out.

1903.	Ullensvang.	Bergen.	Mendal.
January	0.7° C	1.3° C.	0.2° C.
February	2.1	2.9	3.5
March	3.8	4.7	4.3
April	4.5	5.1	4.6
May	2.7	2.5	10.2
June	13.0	12.3	14.7
July	14.1	13.7	14.4
August	12.4	12.1	13.7
September	11.2	11.7	11.5
October	5.6	7.1	6.6
November	2.5	3.8	3.3
December	1.3	2.8	0.8

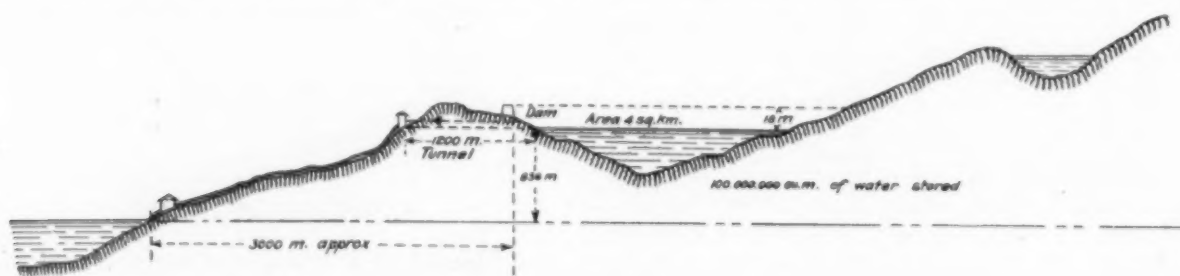
Mean..... 6.6° C. 7.3° C. 7.3° C.

Most characteristic, however, for these regions is the enormous quantity of rain and snow which falls on these high plateaus. The storms coming from the ocean bring along clouds, which, when they approach the coast, are forced to rise somewhat like 1000 meters or more. Rain results, and the water collects in the great natural reservoirs on top of the plateaus.

I would like to give some further data concerning one fall, which, in the course of the last few years, has been fully investigated and which is particularly characteristic for most of the falls in the north and west of Norway.

This waterfall is situated on the Hardanger Fjord, near a port always free from ice and open for the whole year for the largest ocean vessels. The water power available during the entire year, day and night, would be more than 26,000 hp if a single dam of 18 m height for storage of the water would be erected.

The adjoining sketch shows that the height of the fall is 863 m (the figure 836 in the diagram being a mistake and 863 should be substituted). The distance of the dam from the ocean is about 3 km. The water would have to be carried through a tunnel of 1200-m length and then run down through steel tubes to the power station. A further dam erected in con-



SKETCH OF NORWEGIAN WATER POWER.

iron and steel in Norway would be less favorable than they appear to us now. It may be of interest to your readers to state some facts concerning the water powers available in Norway, and especially those in the west and the north of Norway.

The hydrographic chart of Norway shows that the western coast, which is sharply cut up by fiords, rises rapidly from the sea to high plateaus with large reservoirs and immense glaciers, like the Folgefond, which is the largest glacier in Europe.

Moreover, the climate is remarkable, the mean temperature being rather high. This is due to the gulf stream. According to the following table, the mean temperature during different months of the year at three places at the coast, Ullensvang,

nection with the little lake higher up would permit the utilization of some 30,000 hp.

According to the tenders received from leading European and American firms, the electric horse-power developed would cost about 165 francs (\$33), to which would have to be added the price for the waterfall, about 30 francs (\$6) per horsepower; and of the ground, which should be, without doubt, not more than 1 franc (20 cents) per square meter. The total cost to the owner should not be more than 30 or 35 francs (\$6 or \$7) per hp-year, and this is right at a harbor free from ice in an excellent populated district.

KRISTIANIA, NORWAY.

ALBERT HIORTH.

The Bunsen Monument in Heidelberg.

On August 1 many prominent chemists and chemical engineers from all parts of Germany assembled in Alt Heidelberg to attend the unveiling of the statue of Robert Bunsen. The monument, which stands in the park opposite the Märzgasse, is the work of Professor Volz, in Karlsruhe. The necessary funds had been subscribed for by individual chemists and by the large German chemical corporations.

The bronze statue of Bunsen forms the center of the monument. On the two sides of the flight of stairs which lead up to the statue are two figures, one representing science hidden, the other science free. These figures as well as the stairs are made of Black Forest granite.*

Geheimrat Prof. Th. Curtius was the first speaker. He presented in the name of the committee the monument to the city and gave a brief sketch of Bunsen's work in Heidelberg. Bunsen



BUNSEN MONUMENT IN HEIDELBERG.

sen came to Heidelberg in 1852. For 13 years he had already carried out important research work in Marburg and Breslau with respect to cacodyl compounds, the blast-furnace process, the composition of the earth crust, etc.; he had already invented the "Bunsen cell" and had succeeded in producing magnesium by electrolysis.

On Aug. 6, 1852, Bunsen became professor of chemistry at the University of Heidelberg and director of the chemical laboratory in the Dominican Monastery. At the same time funds were promised him for a new laboratory. This was erected in the years 1853 to 1855.

Bunsen felt at once at home in Heidelberg and was on excellent terms with the political powers in Karlsruhe, as appears from a letter written by him on Oct. 29, 1852, to a friend: "Es lebt sich himmlisch hier, in Heidelberg. Ich sehe schon jetzt, dass ich diesen Schritt nie bereuen werde In Karlsruhe weiss man nicht, was man mir alles zuliebe tun soll. . . . Mir wird oft angst und bange, wie ich so grossen Erwartungen entsprechen soll."

In continuation of his work on magnesium he now carried out the production of aluminium, sodium, barium, calcium and lithium by electrolysis of the fused chlorides. For the determination of the specific heat of the new metals and their atomic

*In the *Zeitschrift für Electrochemie*, Sept. 25, from which the accompanying illustrations are reproduced, E. Cohen refers to the words of Sir Humphry Davy with respect to the use of granite: "In all cases when great public monuments are to be erected this is the stone that should be employed."

weights he devised the ice calorimeter. Together with Roscoe he carried out from 1852 to 1862 photochemical investigations which have become classical. Together with Kirchhoff he visited in 1862 Roscoe in England. The photograph reproduced below was taken at that time in Manchester.

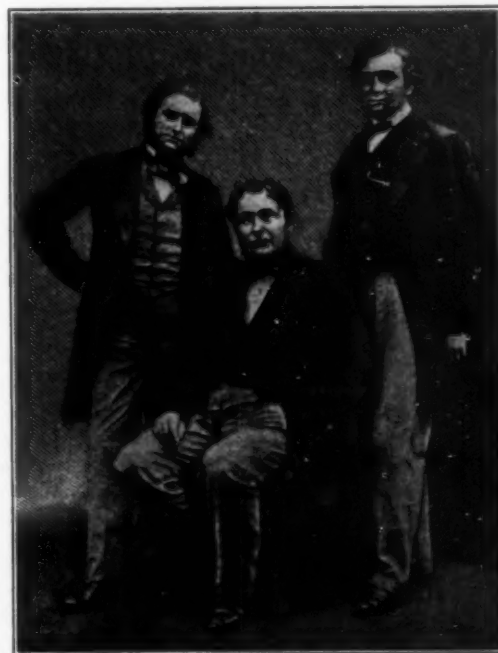
In 1860 the first joint paper by Bunsen and Kirchhoff on spectral analysis appeared. In this investigation the "Bunsen



ROBERT BUNSEN.

burner," which he had devised in 1855, did excellent service. The spectral-analytical work led to the prophecy of new elements and this was fulfilled when Bunsen himself isolated rubidium and caesium during the next year. He then developed many analytical methods and wrote *Gasometrische Methoden* (1857) and *Flammenreaktionen* (1880).

In the laboratory Bunsen trained his students chiefly in the different branches of analytical chemistry and never got tired



R. BUNSEN, G. KIRCHHOFF, H. ROSCOE (1852).

to teach the beginners all the little methods and tricks which he had himself invented. At the age of 78 years he retired as professor in 1889 and enjoyed the rest of his life quietly in Heidelberg. He died on Aug. 16, 1899.

After the conclusion of Professor Curtius' speech, which was the chief address of the day, Dr. Wilckens, as mayor of the city of Heidelberg, accepted the monument for the city. He spoke of Bunsen as man, of his kindness and modesty, and of the love and admiration which all Heidelberg citizens entertained for him.

Geheimrat Britschli, representing the mathematical-physical faculty of Heidelberg University, announced that the faculty

had conferred the honorary degree of doctor of philosophy to Adolf von Baeyer in Munich and Jakobus Henricus von't Hoff in Berlin.

The German Bunsen Society (which erected to Bunsen another monument, *aere perennius*, a few years ago, by gathering his complete papers in three handsome volumes) was represented by its president, Dr. Paul Marquart. Among the many other speakers were Landolt for the Deutsche Chemische Gesellschaft, Caro for the Verein Deutscher Chemiker, Holtz for the Verein zur Wahrung der Interessen der Chemischen Industrie Deutschlands and Bernthsen for the chemical industry.

In the name of the Grand Duke of Baden, Minister von Dusch placed a laurel wreath at the foot of the monument, while another wreath was laid down in the name of Bunsen's friend of many years, Sir Henry Roscoe.

The Complete Analysis of Brass.

BY ALBERT J. HALL.

The present up-to-date foundryman is surely, though perhaps slowly, bringing the operations of the foundry to a scientific basis. The chemist is his co-partner in the work. An accurate knowledge of the composition of his metals is very essential, and must be had to practice economy and to remedy evils existing in the metals due to an excess of certain constituents, or to the presence of impurities in amounts detrimental to the alloy.

In present practice, the routine analysis of the cast work is for copper, tin, lead, and zinc. This is necessary to regulate and keep uniform the various formulæ used. In the case, however, of the analysis of dust or borings returned from the brass shop, foreign scrap, and composition ingot metal, all of which are used in the cheaper castings, iron and antimony determinations become necessary. These determinations regulate the amount of remelted metals used in each furnace heat so as to keep the iron and antimony content in the castings below the detrimental limit.

In red brass of average composition, the tin content usually runs from 1.5 to 10 per cent; the lead from 2 to 12 per cent; the copper from 75 to 90 per cent; and the zinc from 1.5 to 15 per cent. The iron is usually below 0.30 per cent, the antimony below 0.5 per cent, and the arsenic below 0.5 per cent.

In yellow brass the zinc runs up to 40 per cent and the copper lies between 60 and 75 per cent.

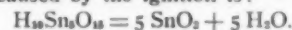
Tin Determination.

Weigh out very accurately 2.5 grams of brass. Transfer it to a 250-c.c. beaker; add enough water to cover it and then add 10 c.c. of nitric acid, sp. gr. 1.42. Immediately cover it with a watch glass and add more water if the action becomes too violent. Heat until all the metal is dissolved or until the metal is completely decomposed. Add about 40 to 50 c.c. of hot water and boil for about five minutes. At this dilution, the tin will completely precipitate. Let the precipitate of metastannic acid settle, then filter through a number 589 white ribbon S. and S. brand filter paper or one equally as good.

If a filter paper suitable for holding a lead precipitate is used, too much time is consumed in filtering. In any case, the filtering will be accelerated by having a clean funnel and having a filter paper fit the funnel exactly, for then, the funnel stem will completely fill with liquid and a natural suction will be produced; thereby increasing materially the rate of filtering. Too much stress cannot be put on these seemingly unimportant details in all cases wherever rapid filtering is desired.

Wash thoroughly with a hot 2 per cent solution of nitric acid. Dry the filter paper with the precipitate in an oven, ignite in a clean weighed porcelain crucible, observing the usual precautions of slow charring and burning of the filter paper. When the filter paper has burned off, put the crucible in full heat of the burner for ten minutes or in a blast lamp for five minutes. Cool the crucible partly in the air, then finally in a desiccator. Weigh as tin oxide SnO_2 .

The reaction caused by the ignition is:



From the weight of tin oxide found, calculate the per cent of tin present.

If there is any antimony in the alloy, it will be precipitated with the tin and weigh up as Sb_2O_3 . After the antimony determinations, calculate the weight of Sb_2O_3 present here and deduct it from the combined weights of SnO_2 and Sb_2O_3 . Then calculate the per cent of tin. (See Antimony Determination.)

Lead Determination.

The filtrate from the tin contains the nitrates of copper, lead, and zinc. Add 10 c.c. of sulphuric acid, sp. gr. 1.84, and evaporate on a water bath or hot plate until all the nitric acid is driven off and the metals are in the sulphate condition. The change of color from dark blue to light blue or gray is an indication of the absence of nitric acid. It is a great saving of time to arrange the work so that the filtrate can be evaporating on the steam bath over night. In the morning, all the nitric acid will be gone and the analysis ready to be continued. The steam bath is by far the more satisfactory for it can be run over night and, moreover, there is no danger of spattering as is the case when on a hot plate.

When all the nitric acid is removed, cool a few minutes, then add about 200 c.c. of hot water, and dissolve the sulphates of copper and zinc. The lead will be left as a white precipitate. Heat the solution to the boiling point, then let it cool and the precipitate of lead sulphate settle. Filter through a fine, firm filter paper, and wash very thoroughly with a 5 per cent solution of sulphuric acid. Remove the filtrate, and finish the washing with a solution of alcohol and water in proportion 1:1. The purpose of the washing with alcohol, which ought to be very thorough, is to remove the sulphuric acid as its presence in even very small amounts causes a disintegration of the filter paper during the drying, and renders subsequent removal of the precipitate impossible.

When all the sulphuric acid is removed, as shown by testing the washings with hydrochloric acid and barium chloride, dry the filter paper in an oven. Open the filter paper and carefully remove the precipitate by means of a clean spatula and camel's hair brush to a piece of glazed paper. Cover the paper with a watch glass to prevent the escape of some of the precipitate which might otherwise be blown away by draughts. Fold the paper and burn it on a platinum wire over a weighed porcelain crucible. Jar the ashes, and any unburned paper, due to poor washing with alcohol, off the wire and put the crucible over the lowest possible flame and finish the burning. A low temperature is very essential.

Even with the best precautions, some lead sulphate that stuck to the filter paper will be reduced to metallic lead by the action of carbon and on heating it will be oxidized to lead oxide PbO . If the temperature is high the lead volatilizes. When the filter paper is burned, allow the crucible to cool slightly. Add three drops of nitric sulphuric acid made up in the proportion of three parts nitric acid and one part sulphuric. Now put the crucible on the edge of a hot plate and leave until all the nitric acid has evaporated. This will take only a few minutes. Then move to the center of the hot plate, and drive off all the sulphuric acid. Be sure that no acid is left condensed on the sides of the crucible. The lead and lead oxide are thus all converted to lead sulphate. Remove the crucible from the hot plate and allow it to cool. Then add the main bulk of the precipitate, and put the crucible over a very small flame for four or five minutes. Do not let the bottom of the crucible get above a light cherry-red color. Cool as before, first in the air, and then in a desiccator. Weigh as lead sulphate. From this weight, calculate the per cent of lead present.

Copper Determination—By Electrolysis, Using Rotating Anodes.

Dilute the filtrate from the lead precipitate to exactly 500 c.c. in an accurately graduated volumetric flask. Shake the solution

thoroughly in order to make it uniform throughout. Take one-tenth of this filtrate, viz., 50 c.c., and use it for both the copper and zinc determinations. Dilute this 50 c.c. to about 125 c.c., preferably in a tall non-lipped 150-c.c. beaker. Add 2 c.c. of acid (3 parts nitric and 1 part sulphuric), and $\frac{1}{2}$ gram ammonium nitrate. Heat the solution to almost boiling and plate out the copper on platinum gauze cathodes using a current N. D. 100 equal to 4-5 amp for each cell. The pressure should be at least 3 to 4 volts for each cell. Rotate the anode about 600 to 800 times per minute. Cover the beaker with split watch glasses to prevent a loss of liquid due to the rapid evolution of gas from the anodes. The copper will be precipitated in from 20 to 25 minutes.

When the precipitation of the metal is complete, which may be ascertained by removing a drop or two with a capillary tube or dropper, and bringing it in contact with a drop or two of hydrogen sulphide water; a brown coloration indicating copper; reduce the current to about 2 amp, never below,* and remove the cathodes. Wash them well when removing them, taking care that neither cathode remains in the liquid an instant after the current is broken. This is done by short-circuiting the one being removed when the connection is broken and letting the current pass through the second one until ready to be removed. Wash the cathodes in alcohol, and then dry them in an oven at 100 deg. Cent., care being taken to see that they do not remain in the oven longer than is necessary to dry them. Otherwise, oxidation may take place and the determination will be spoiled. A quicker way of drying the cathodes is to cautiously hold them over an open flame, an Argand burner preferred, until just dry. Cool in a desiccator, and weigh as metallic copper. The weight multiplied by 10 gives the weight of copper in the whole sample. From the weight obtained, calculate the percentage of copper present.

The deposit, if a good one, will be smooth, adherent, hard, and a salmon pink color. Duplicates should check within 0.3 or 0.4 of a milligram or the determination should be rejected.

A plating very red in color is an indication of too much acid. A spongy deposit at the bottom is a manifestation of too much current for the concentration of the copper ions in the liquid.

For stationary anodes, the current should be very materially reduced (to about 0.5 amp) and the time taken for the plating would be about 12 to 15 hours.

Copper Determination—Volumetric Method.

The method used is that of Low.**

STANDARDIZATION OF THE THIOSULPHATE SOLUTION.

Prepare a solution of sodium thiosulphate containing about 19 grams of the pure crystals to the liter. Standardize as follows: Weigh accurately about 0.200 gram of pure copper foil, and place in a flask of about 250 c.c. capacity. Dissolve by warming with 5 c.c. of a mixture of equal volumes of strong nitric acid (sp. gr. 1.42) and water and then dilute to about 50 c.c. Boil for a few moments to partially expel the red fumes and then add 5 c.c. of strong bromine water and boil until the bromine is thoroughly expelled. The bromine is to ensure the complete destruction or removal of the red fumes.

Remove from the heat and add a slight excess of strong ammonia water. Ordinarily it suffices to add 7 c.c. of ammonia water of 0.90 sp. gr. Again boil until the excess of ammonia is expelled as shown by a change of color of the liquid and a partial precipitation of the copper hydroxide or oxide. Now add strong acetic acid in slight excess, perhaps 3 or 4 c.c. of the 80 per cent acid in all, and boil again for a moment if necessary to redissolve the copper. Cool to room temperature and add about 3 grams of potassium iodide or 6 c.c. of a solution of the salt containing 50 grams in 100 c.c. Cuprous iodide will be precipitated and iodine liberated according to the reaction



*If the current is reduced too much, the counter current generated may dissolve off some of the deposit.

***Jour. Amer. Chem. Soc.*, Vol. 24, p. 1082.

The free iodine colors the mixture brown. Titrate at once with the thiosulphate solution until the brown tinge has become weak and then add sufficient starch liquor to produce a marked blue coloration. Continue the titration cautiously until the color due to free iodine has entirely vanished. The blue color changes toward the end to a faint lilac. If at this point the thiosulphate be added drop by drop and a little time be allowed for complete reaction after each addition, there is no difficulty in hitting the end point within a single drop. One c.c. of the thiosulphate solution will be found to correspond to about 0.0005 gram of copper. The reaction between the thiosulphate and the iodine is



Sodium iodide and tetrathionate are formed. The starch liquor may be made by boiling about 0.5 gram of starch with a little water and diluting with hot water to about 250 c.c. The liquor should be homogeneous and free from lumps or grains. It should be used cold and must be prepared frequently, as it does not keep well. The thiosulphate solution made from the pure crystals and distilled water appears to be quite stable, showing little or no variation in a month under reasonable conditions.

For the determination use 50 c.c. of the filtrate from the lead determination. Put it in a flask, add ammonia, boil off excess, add acetic acid, and titrate exactly as described for the standardization. From the amount of the thiosulphate solution used calculate the percentage of copper present.

Zinc Determination—By Electrolysis, Using Rotating Anodes.

Evaporate the filtrate from the copper determination by electrolysis, which must be free from copper, on a steam bath until the volume of the solution is 3 to 4 c.c. To insure the complete removal of the nitric acid, which is very essential, heat the beaker containing the filtrate over a flame keeping the beaker in constant motion to prevent spattering until dense white fumes from the sulphuric acid are given off freely. This operation takes about two to three minutes. Cool the beaker in the air, then add 120 c.c. of water and 6 grams of solid sodium hydroxide. (Too much sodium hydroxide produces a poor black deposit which is always too heavy.) Warm and stir the solution until all the sodium hydroxide is dissolved. Heat to about 60 deg. Cent. and plate out the zinc, using a current N. D. 100 equal to 4 amp for each cell. The pressure is generally about 5 to 6 volts for each cell.

For each zinc determination use the copper plated cathodes from the copper determination, as zinc plated on platinum produces platinum black which is very hard to remove and which materially diminishes the weight of the cathodes. A silver plated cathode may be used instead of a copper plated one, if it is desired. Have all the connections made and some current on so that the plating starts immediately after the cathode touches the liquid. The anode should make about 600 revolutions per minute. The zinc will be plated out in 25 minutes.

When the metal is completely precipitated, which may be ascertained by removing a small quantity of liquid, acidifying it with sulphuric acid, and bringing it in contact with a drop or two of a solution of potassium ferrocyanide (the presence of zinc producing a cloudiness in a very short time), reduce the current to 2 amp, as in the copper determination, and remove the cathodes, using the same precaution as required for the copper determination. Wash the cathodes in alcohol and dry as before in an oven or over a naked flame. Cool in a desiccator, and weigh as metallic zinc. The weight multiplied by 10 gives the weight of zinc in the whole sample. From the weights obtained, calculate the percentage of zinc present. Duplicates should check within very close limits.

The deposit, if a good one, will be hard, adherent, and light gray in color.

The copper plated cathodes can be used for several zinc determinations by dissolving the zinc off the cathodes in rather dilute nitric acid. If the cathodes are allowed to remain in the

acid solution only a moment, the copper layer will be but slightly attacked, and after washing in alcohol and drying, they will be ready for another deposition of zinc.

The method as given above applies only to rotating anodes. With the stationary anodes, I would add 2 to 4 grams solid sodium hydroxide, dilute to 125 c.c., heat to 50 deg. Cent., and electrolyze with a current of N. D. 100 equal to 0.7 to 1.5 amp. All the metal ought to be deposited in about two hours.

Another method that has found favor with some chemists is to mix the solution of zinc sulphate, neutral as possible, with an excess of neutral potassium oxalate until the precipitate, which at first appears, redissolves. Heat the solution to 50 or 60 deg. Cent. and electrolyze with N. D. 100 equal to 0.5 to 1.5 amp. About two hours will be sufficient for complete precipitation.

If there is any iron present, it will be precipitated with the zinc. Dissolve off the zinc in dilute hydrochloric acid and precipitate the iron by ammonium hydroxide. Filter off the precipitate, dissolve it in hydrochloric acid, reduce it with stannous chloride solution and titrate the iron with a standard solution of potassium permanganate. From the amount of the solution used determine the amount of iron present. Subtract the iron found from the weight of zinc.

Zinc Determination—Gravimetric Method.

The method used depends on the precipitation of zinc as zinc ammonium phosphate and its subsequent ignition to zinc pyrophosphate. It is carried out as follows: Take 250 c.c. of the filtrate from the lead determination, containing copper and zinc as sulphates. To remove the copper, add 35 c.c. of sulphurous acid, heat to boiling and add 5 or 6 grams of ammonium sulphocyanate. If the precipitate of copper sulphocyanate is not white or cream color, add more sulphurous acid. Allow the precipitate to settle, then filter off and wash with hot water. Use a fine filter as the precipitate sometimes has a tendency to run through. To the filtrate from the copper sulphocyanate, add 35 c.c. of ammonia water (sp. gr. 0.90) or enough to make strongly alkaline, and 50 c.c. of a 10 per cent solution of ammonium phosphate. The presence of an excess of ammonium phosphate decreases the solubility of the zinc ammonium phosphate.

Make up to approximately 500 c.c., heat to boiling and cautiously neutralize with nitric acid (sp. gr. 1.20) added from a dropper until a slight permanent turbidity is produced. Then discontinue the addition of nitric acid and add acetic acid (1:25) 1 c.c. at a time from a dropper. Continue the addition until only a faint odor of ammonia is perceptible. Heat the solution up again to boiling and stir until the precipitate is granular. If the precipitate does not become granular after considerable stirring, it is best to dissolve it in ammonia and reprecipitate as directed above.

Filter off the precipitate of zinc ammonium phosphate, wash with cold water, ignite carefully in a platinum crucible and weigh as zinc pyrophosphate $Zn_2P_2O_7$. From this weight, calculate the percentage of zinc present.

The copper may be removed, before precipitating the zinc, by hydrogen sulphide, but the separation by ammonium sulphocyanate and sulphurous acid is much the neater of the two.

Iron Determination.

Weigh out 5 grams of the sample turnings, previously freed from iron filings, etc., by a magnet, into a 250-c.c. beaker or a 250-c.c. casserole, preferably the latter. Add about 40 c.c. of water and then 20 c.c. of nitric acid, sp. gr. 1.42. Heat until the metal is completely disintegrated. Then add 15 c.c. of sulphuric acid, sp. gr. 1.84, mixed with an equal quantity of water. Put over the steam bath and evaporate off all the nitric acid. Dilute to about 200 c.c. and boil for a minute or two. Let it settle and cool. Filter out the tin and lead precipitate and wash with a 5 per cent solution of sulphuric acid. The iron is in solution in the filtrate. Dilute the filtrate to about 750 to 800 c.c. in a liter beaker. Heat the solution to boiling

and add concentrated ammonium hydroxide until the solution turns a very dark blue color. It is an indication that the copper and zinc which were precipitated at first are redissolved. The iron will be precipitated as ferric hydroxide. It is necessary to have the bulk of the solution about 800 c.c. before precipitating the iron in order to keep the zinc in solution.

Boil the solution about five minutes, let it settle and then filter through a thin, rapid filtering, filter paper. Wash the precipitate with hot water containing a little ammonia. Put a 250-c.c. Erlenmeyer flask under the funnel and dissolve the ferric hydroxide off the filter by means of hot concentrated hydrochloric acid. Wash the filter paper very thoroughly with hot water, and then put on more acid and follow it with more hot water. Two or three such applications are sufficient to dissolve off all the precipitate. Put the flask over a burner and heat to boiling. Then add sufficient stannous chloride solution to completely decolorize it. Remove the flask from the fire and according to Blair's method for iron add 60 c.c. of mercuric chloride solution. Put under running water and cool as soon as possible.

In a large porcelain evaporating dish, put 600 c.c. of water and 60 c.c. of phosphoric acid solution. When the iron and mercuric chloride solution is cool, add it to the solution in the evaporating dish. Rinse out the flask into the dish and titrate the iron at once with a standard solution of potassium permanganate. Add the latter until a permanent tinge of pink is produced. If beyond the end point, titrate back with an equivalent standard solution of ferrous sulphate. Subtract the number of cubic centimeters of ferrous sulphate solution used from the number of cubic centimeters of permanganate solution required. From the data obtained, calculate the percentage of iron present.

Standardization of Potassium Permanganate.

Weigh out 100 to 150 mgs. of small pieces of iron wire of known purity. Have the pieces clean and bright. Put in an Erlenmeyer flask, pour on 60 to 70 c.c. of water and add 2 grams of sodium bi-carbonate. Shake until the carbonate is all dissolved. Add 6 or 7 c.c. of sulphuric acid, sp. gr. 1.84, and put an inverted crucible cover over the flask so that there is an atmosphere of carbon-dioxide over the solution. Put on the fire and keep at the boiling point until all the iron is in solution. Remove the flask, keeping the cover on, and cool the solution under running water. Now remove the cover, rinse down the sides of the flask with water and titrate at once with the permanganate solution. When the ferrous sulphate is all oxidized, one drop of permanganate will give a slight but permanent pink color to the solution. Observe the amount of permanganate solution used. From the reading obtained, the equivalent of one cubic centimeter of permanganate solution in iron can be calculated.

The solutions used in the iron analysis are made up according to Blair.

Mercuric Chloride Solution.

Dissolve 50 grams of mercuric chloride in one liter of water and filter.

Phosphoric Acid Solution.

Dissolve 200 grams of crystallized manganous sulphate in one liter of water. Add a few drops of sulphuric acid and filter. Add to this one liter of phosphoric acid, sp. gr. 1.3, 600 c.c. of water and 400 c.c. of sulphuric acid, sp. gr. 1.84.

Antimony Determination.

Take a 5-gram sample. If the brass is low in tin, add some pure tin, otherwise the antimony will not be completely precipitated. Dissolve in 50 c.c. of nitric acid, sp. gr. 1.20. Evaporate the solution to about 10 or 12 c.c. and then dilute to about 350 c.c. in a 500-c.c. Erlenmeyer flask. Boil for about 10 minutes and then let it settle with the flask at an angle of 45 deg. When the solution has settled well, carefully decant as much of the solution as possible, but do not lose any of the precipi-

tate. If the precipitate does not settle out well, decant through a filter paper and return the precipitate and paper to the flask. The presence of the paper will not have any effect on the titration. If much copper is present, add 300 c.c. of hot water, and let it settle as before and decant again. The object is to get rid of most of the copper. Add 15 c.c. of concentrated sulphuric acid and 4 or 5 grams of potassium sulphate to the flask and evaporate to white fumes. Then add $\frac{1}{2}$ gram of powdered tartaric acid. Heat quite strongly over asbestos until all the organic matter is dissolved. This can be told by the solution turning white or very light colored. This leaves the antimony and tin in the proper states of oxidation. Cool. Add 50 c.c. of water and 10 c.c. of hydrochloric acid, sp. gr. 1.20, and heat to solution of all that is soluble. Cool very thoroughly, using ice if obtainable. Add 120 c.c. more water and 10 to 12 c.c. more hydrochloric acid. Cool again, and then titrate with potassium permanganate solution.

The end point is distinct, but it fades quite quickly, so do not add more permanganate. The presence of more hydrochloric acid causes the end point to be hard to find.

The standard permanganate solution must be standardized by C. P. antimony, then the personal error in the end point here will be the same as in the regular antimony determination. In this way all errors in readings are eliminated. Otherwise, the antimony determination will probably be too high. Calculate the percentage of antimony present. Multiply the weight of antimony by 1.2658 and subtract it from the weight of SnO_2 and Sb_2O_3 as weighed up in the tin determination. The difference multiplied by 0.7881 equals tin.

Standardization of Permanganate Solution by Antimony.

The method used is that of Low* and is carried out as follows: Take 0.1202 grams of C. P. antimony and 0.1190 grams of C. P. tin. Put in a 500-c.c. Erlenmeyer flask and add 10 c.c. sulphuric acid, sp. gr. 1.84, and 3 or 4 grams of potassium sulphate. Heat until the metals are in solution or until the alloy is decomposed and all separated sulphur boiled off. Do not drive off all sulphuric acid. Do not let the melt get hard on cooling. About 7 to 10 c.c. is enough. Cool. Add 50 c.c. of water and 10 c.c. of hydrochloric acid, sp. gr. 1.20, and heat to get all possible into solution. (A little tartaric acid may be added here, but it is not necessary for so small amount of antimony as is present here.) Cool the solution, and add about 110 c.c. more water and 20 c.c. more of hydrochloric acid, sp. gr. 1.20. Cool very thoroughly, and titrate at once with potassium permanganate.

Arsenic Determination—Distillation Method.

Dissolve 20 grams of ferrous oxide (Fe_2O_3) in 150 c.c. strong hydrochloric acid. Boil for 10 or 15 minutes. Put in a distillation flask with 10 grams of brass. Distill off the arsenic, or until the solution in the flask is quite thick. Dilute the distillate to about 300 c.c. Nearly neutralize with solid potassium hydroxide, keeping cool while adding the hydroxide. Finish neutralizing with sodium bi-carbonate. Titrate with $n/100$ iodine solution. The iodine solution ought to be standardized each time a determination is made if made on different days.

For the standardization, use 0.1 gram arsenous oxide (As_2O_3). Add 50 c.c. of water and an excess of potassium hydroxide. Make up the solution to exactly 500 c.c. and take one-tenth for a sample. Treat exactly as in the arsenic determination.

The arsenic determination is seldom made on brass, because its presence in such small quantities seems to have no deleterious effect on the alloy. This determination, however, is often made on virgin copper and this method can be used.

Remarks.

The details of analysis have been given in full for the benefit of many a man who is called upon to make the determinations without any practical experience in this one line. It is the firm belief of the writer that any man with a common amount of

technical training and reasonable ability can make the complete analysis of brass with accuracy without having to look up any references or go into the work half blindly due to the vagueness or incompleteness of methods.

Electrolytic determinations are becoming more widespread and finding broader application each year. Electrolytic methods are very applicable to the analysis of brass and the quicker the brass man puts in a laboratory with an electrical equipment the better. They are more accurate than other methods, and a great time saver.

It is the belief of many that the time will soon come when the chemist will be to the brass foundry what he is to the iron and steel works, an absolute necessity.

I am greatly indebted to Mr. W. M. Corse for many general suggestions that he has offered me while working out these methods, or adapting them to the analysis of brass, and for his kindness in looking over the manuscript.

The Production of Finished Iron Sheets and Tubes in One Operation.*

By SHERARD COWPER-COLES.

Hitherto it has been the universal custom to produce iron or steel sheets, tubes, and wire by a process of smelting the iron, refining, cementation, annealing, rolling, or drawing. The object of the present paper is to describe an electrolytic process for making tubes, cylindrical vessels, sheets, and wire in one or two operations from crude or scrap iron, or direct from the ore, without the processes of smelting, rolling, or drawing, at a cost that has hitherto been thought impossible.

It is generally believed that iron and other metals refined by electrolysis are quite free from those impurities which are invariably associated with metals produced by a smelting process. Electrolytic iron can be obtained almost chemically pure when special precautions are taken, but even then, when the product is made to form the poles of an electric arc lamp and the spectrum is carefully examined, there is evidence of the presence of minute quantities of impurities.

One of the first, if not the first, to mention iron produced electrolytically, was Bockbushmann in 1846. He deposited on a copper matrix a plate of iron 150 millimeters square (5.9 inches) and 2 millimeters thick (0.079 inch).

In 1857 Feuchner exhibited specimens of electrolytic iron at the Paris Exposition. Alfred Smee in his book on electrometallurgy, printed in 1851, makes the following remarks: "The reduction of iron, from a pecuniary point of view, is the very worst process in the whole range of electric metallurgy, for the metal is scarcely worth anything in comparison with others. Iron masters doubtless sleep in perfect security when they are told that from one equivalent of galvanic power derived from my battery, costing one-twentieth of a penny, 28 grains of iron are reduced, so that the reduction of one pound of iron, worth about a penny, would cost more than a shilling for the bare materials used in its production, added to the value of the metal. In this aspect of affairs not only the blast, but even the puddling and smelting furnaces, are likely to continue to send forth their pestiferous fumes by day and their pandemonium-looking flames by night, corrupting the atmosphere to the injury of vegetation, as well as to the detriment of the health of human beings."

Since Alfred Smee made this remark forty-seven years ago, great progress has been made, the cost of the electrolytic process having been reduced from over a shilling per pound for iron in a rough form, which required smelting and rolling, to about a halfpenny for iron obtained in a finished form capable of realizing the highest market value.

Up to the present time the process of electrodeposition of iron has been confined to the facing of engraved copper plates for fine printing, such as bank notes, as iron has the advantage

**Jour. Amer. Chem. Soc.*, Vol. 29, p. 66. This article contains directions for titrating for tin as well as antimony.

*A paper read at the September meeting of the Iron and Steel Institute. Abridged.

of being easily removed with acid when worn through, thus enabling the iron facing to be removed without damage to the copper plate.

Klein introduced a process in Russia for the production of iron electrotypes for bank-note printing—that is, the plates were made of solid electrolytic iron instead of being copper faced with iron. The electrolyte used was composed of ferrous and magnesium sulphates, a current density as low as 0.30 amperes per square decimeter being necessary, one and a half months being required to give a thickness of 2 millimetres (0.079 inches).*

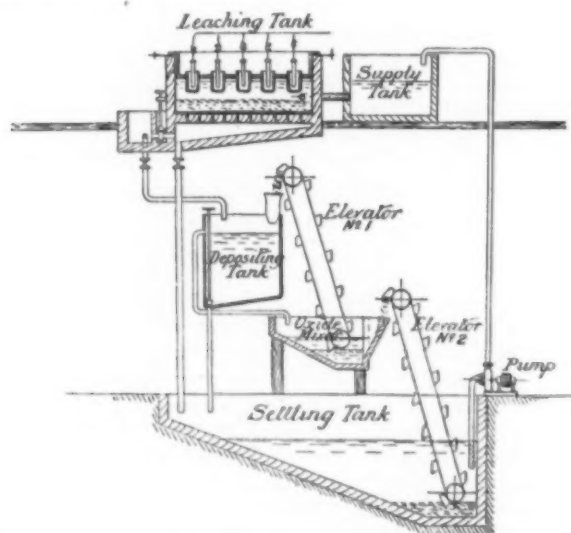


FIG. 1.—GENERAL ARRANGEMENT OF PLANT.

The author in the year 1898 made a number of experiments on the production of electrolytic iron plates, and produced plates of considerable thickness, but in such a rough condition that they required smelting and rolling; the rate of deposition, moreover, was so slow as to render the process impracticable, and it was not until the year 1900 that he succeeded in obtaining some small tubes.

The results obtained were a great advance on what had hitherto been effected, but were not far enough advanced to be turned to practical account; it was not until the present year that sheets and tubes were obtained of a quality equal to steel, and with a surface that required no after-treatment, such as rolling or drawing.

An electrolytic iron production process, to be of commercial value, must fulfil the following conditions: The voltage between the terminals of the depositing cell must be low, the current density per square foot of cathode surface must be high, and the iron or steel deposited must be in such a form that it can be used for industrial purposes without smelting. An electrolytic process that fulfils these conditions must revolutionize many branches of the iron trade, as it will enable thin iron tubes and sheets in particular to be produced at a very low cost, and without the necessity of burning coal.

The process briefly consists in placing crude iron (which may contain those elements which are at present so detrimental to the production of high-class iron or steel), or finely divided iron ore, in suitable containing vessels in which an acid solution is circulated using an insoluble anode material**; or, further,

*Mr. Cowper-Coles' paper gives here a series of tables of the e.m.f. required for iron refining with different electrolytes and at different temperatures. Concerning the electrolytic iron refining process of Burgess and Hambuechen, see our vol. II. page 183.—Ed.

**Since it is stated later on that the crude iron or iron ore is connected to the positive pole of the electric circuit, it represents the real anode, and any "insoluble anode" which may be used must be in contact with the crude iron or iron ore, and serves simply for conducting the electric current to the latter. The description of the process, and especially the explanation of Fig. 1, is not very clear, though it is taken verbatim and in full from Mr. Cowper-Coles' paper. A further paper embodying the results of work now in progress is promised by the author for a future date.—Ed.

the process may combine the use of soluble and insoluble anodes. The crude iron or iron ore being in each case connected to the positive pole of a dynamo, the iron goes into solution, and is deposited on cylinders or plates which may be either rotated or stationary, depending upon the class of finished product required.

Fig. 1 represents the general arrangement of the apparatus employed when depositing iron from crude iron or the ore. In the former case the iron is arranged around the cathode, and in the latter insoluble anodes, of graphite, for example, a small electric current being employed to assist the leaching process.

It is conceivable that in some cases iron might be recovered without mining, acid liquor being circulated over the ore deposits. The process lends itself to the recovery of iron more especially from carbonated ores, "blue billy," Lake, and Bog ores. An electric process will no doubt prove to be a valuable adjunct where pig iron is used for precipitating copper, enabling the iron to be recovered instead of letting it run to waste.

Good results have been obtained from an ore containing:

	Per Ct.
Ferric oxide	50.7
Lime	3.8
Phosphoric acid	1.51
Alumina	10.0
Silica	16.0

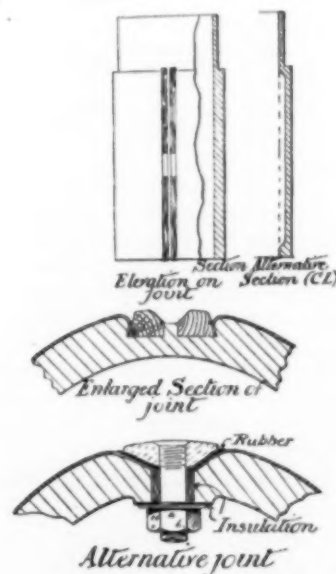


FIG. 2.—CONSTRUCTION OF CATHODE.

When it is desired to produce a highly finished sheet, a metal sheet of the desired surface is wrapped round the cathode, and held in position by means of grooves and wedges, as shown in Fig. 2.

In this way, sheets of large dimensions can be made; by employing a mandrel, say, 8 feet in diameter, a sheet 24 feet by 5 or 7 feet can be produced.

When it is desired to produce tubes, iron mandrels somewhat smaller than the internal diameter of the finished tube are coated with lead by electro-deposition, or by having lead drawn over them. Thus prepared, the mandrels are rotated in such an apparatus as is shown in Fig. 3. When the desired thickness of iron has been deposited, the mandrel is heated to a temperature sufficient to melt out the lead, and thus admit of its easy withdrawal.

The electrolyte employed consists of a 20 per cent. solution of sulpho-cresylic acid saturated with iron. Sulpho-cresylic acid is a cresol-sulphonic acid containing approximately 108 part of cresol and 98 parts of sulphuric acid. The cresol con-

tains ortho, 35 per cent.; meta, 40 per cent., and para 25 per cent. This cresol is heated with sulphuric acid, yielding isomeric cresol-sulphonic acids.

In some cases it is advantageous to add small quantities of carbon-disulphide, the temperature of the solution being about 70° C., the current density about 100 amperes per square foot. The solution is kept charged with iron oxide, which is kept in

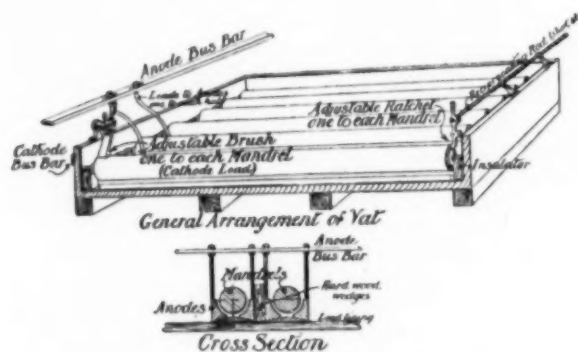


FIG. 3.—APPARATUS FOR DIRECT PRODUCTION OF TUBES.

suspension in the electrolyte by means of stirrers, by moving one or both of the electrodes, or by circulating by means of a bucket pump, as shown in Fig. 1. The specific gravity of the electrolyte having the iron oxide in suspension is about 1.32.

Excellent results have also been obtained by depositing the iron in a closed cell with a vacuum of a few inches, and also with a chloride solution and porous cells, bleaching powder being produced as a by-product; or the chlorine utilized to form fresh iron chloride.

The following are two typical analyses of electrolytic iron produced under the conditions described in this paper:

I.	
	Per Cent.
Carbon (by combustion).....	0.060
Silicon	0.011
Sulphur	0.016
Phosphorus	0.041
Manganese	traces
Arsenic	0.004
II.	
Combined carbon	under 0.05
Silicon	0.048
Sulphur	0.045
Phosphorus	0.04
Arsenic	0.01
Manganese	traces

A peculiar feature of electro-deposited iron is that it creeps to an extraordinary degree with a rounded, smooth edge over any material; in fact it is difficult to stop its spreading. Under certain conditions, when employing a rotating cathode, long tentacles form, 6 inches or more in length, in the direction of rotation with approximately the same curvature as the mandrel.

Amongst other applications the process can be applied to the production of bimetallic tubing and plates; that is to say, to tubes or sheets coated on the one side with copper or other metals or alloys.

The process can also be applied to the direct production of large sheets or strips representing the cutting surface of a file, and cut up into portions of the desired shapes, and secured to suitable backing, to form separate files. The prints are produced by making a continuous impression or a number of impressions from a suitable die, revolving roller, or reciprocating tool in a lead alloy. The matrix thus prepared is mounted on a revolving drum, and steel deposited by the process which has already been described.

Electrolytic steel, with considerable variation in the percent-

age of carbon, can also be produced. Houllevigue observed that when iron is deposited from iron containing uncombined carbon, the product at the cathode was free from carbon; but when deposited from iron containing combined carbon, the cathode product also contained carbon. The author's observations confirm this statement and at a future date he hopes to publish figures showing the results that can be obtained. The amount of silicon in the iron can also be considerably varied.

An important feature of the electrolytic process will no doubt be the introduction of some new ferro-alloys, which cannot be made by fusion. Alloys of iron and nickel have already been produced electrolytically.

Electrolytic iron sheets can be obtained with a highly finished surface, can be readily welded, coated with tin and zinc by dipping in a molten bath of these metals, coated with zinc by the Sherardizing process, or electro-galvanized.

The structure of electrolytic iron varies considerably; in some cases it is found to be amorphous, while in other instances it possesses a structure somewhat similar to that of wrought iron.

IRON AND HYDROGEN.

The properties of electrolytic iron appear to depend largely on the amount of hydrogen present, and therefore on the annealing, which reduces or eliminates the occluded hydrogen.

Samples tested have given a hysteresis loss of "under 0.3 watt per pound." The iron when charged with hydrogen is magnetic; and when magnetized, becomes a very powerful magnet as compared with ordinary steel.

Electrolytic iron always contains hydrogen in varying quantities, according to the conditions under which it is deposited, and the more hydrogen it contains the greater is its hardness.

The hardest varieties will scratch glass. Longheber has found electrolytic iron to contain 0.2 to 0.001 per cent. of hydrogen. Although these figures appear small when expressed as weight percentage, they represent volumes of hydrogen to iron of between 12 and 110. When high current densities were employed, deposits were obtained containing 110 times their own volume of the gas. Other investigators have obtained even larger percentages of hydrogen.

Electrolytic iron has a tendency, when deposited on a flat surface, to curve outwards—that is, it becomes concave relative to the anode surface when deposited on the cathode. There are two distinct varieties of electrolytic iron, with varying percentages of hydrogen; the softer kind of iron is silver-gray in color, whilst the other variety is very hard and brittle, breaking as readily as glass, and containing a higher percentage of hydrogen. The hardness varies between these two extremes. A surface can be obtained on the latter of a silvery whiteness, and with a mirror finish without polishing, as will be observed by the specimens exhibited. Either quality can be produced at will by increasing or decreasing the electromotive force at the terminals of the cell.

Iron highly charged with hydrogen is very inert, and not readily attacked by acids. The softer quality is also comparatively inert. Equal surfaces of wrought iron and electrolytic iron were immersed in pure hydrochloric acid, 2° Twaddell, for eighteen hours. The electrolytic iron lost 2.48 per cent. of its weight, and the wrought iron 13.13 per cent.

The temperature required for annealing electrolytic iron is slightly in excess of that required for ordinary rolled sheets. Electrolytic iron, when heated in a closed annealing box, gives off large quantities of hydrogen; and if a pipe is fitted to the annealing box the hydrogen flame can be kept burning during the whole process of annealing, and for a considerable time after the heat has been removed from the annealing box. This phenomenon has been turned to account for removing scale from ordinary rolled sheets by placing some sheets of electrolytic iron in an ordinary annealing box with plates to be scaled. Electrolytic iron gives up considerable quantities of its hydrogen under 100° C. without losing its brittleness, and also when boiled in water or oil.

When iron is deposited under magnetic conditions—that is, if a powerful magnet is placed behind the cathode—lines of magnetic force are obtained similar to those rendered visible with iron filings.

CONCLUSION.

The electrolytic production of iron and steel has now emerged from the laboratory or academic stage to a practical conception, enabling iron and steel to be produced in a highly finished form from iron ore or scrap iron, in a condition which realizes the highest market value, by a process which reduces labor to a minimum, and under conditions which can be compared to the working of a central electric light station for cleanliness and health.

In conclusion, the advantages may be summarized as follows:

1. Finished products, such as tubes, sheets and wire can be produced at less cost than by the processes of smelting, refining and rolling.
2. A product is obtained which does not corrode as readily as steel, at less cost.
3. The process can be worked economically when no coal is available.
4. Iron ore that is useless for ordinary smelting operations can be advantageously utilized by the electrical process.
5. The process is a power process, and utilizes but little labor. Small units can be worked economically.
6. The process is more cleanly and healthy than the operations of smelting.
7. Little or no scrap is formed.*

Electrolytic Gold Refining.

By EMIL WOHLWILL, PH. D.

In the March issue of this journal (Vol. VI, p. 114) Dr. J. W. Richards has calculated theoretically the requirements and results of the application of the electrolytic process of gold refining in a special case. In the present article I wish to present a few objections against some points of this calculation.

Dr. Richards chooses as example the electrolytic refining of an alloy containing 60.3 per cent gold, besides known quantities of silver, copper, lead, zinc, iron and nickel. He also assumes arbitrarily, it seems, certain conditions for the operation of the process. On the basis of theoretical considerations he then answers eight questions which are of importance for the practice. I assume that this example and its solution is intended to show to the practical man how to formulate and solve the problems, not only in this special case, but in other cases of gold refining. For this reason I like to present some objections against this special example and some of the assumptions and results.

I will first deal with the calculation of the interest charge, because it is of special importance for the gold refiner who wants to use the electrolytic process, and because it gives an opportunity to also refer to most other points. With anodes of the composition stated above and with the method of operation assumed by him, Dr. Richards obtains the result that the interest charge per kilogram of gold under treatment is 51 cents.

In the strictly scientific paper of Dr. Richards it is not said explicitly that this expense is so large as to prevent the practical refiner from using the process. Nevertheless, the practical man will look at this figure as the chief result of the calculation, if he is not cautious enough to examine carefully the calculation. That it is not free from slips will be seen. Thus the weight of the anodes is calculated from the assumed dimensions of the plates. The plates are 48 cm wide, 20 cm high and 2 cm thick. Since their specific gravity is assumed to be 17.5, each of these

plates weighs $48 \times 20 \times 2 \times 17.5 = 33,600$ grams or 33.6 kilograms. As five such plates are used in 10 tanks, the total weight of the anodes in the 10 tanks is $50 \times 33.6 = 1680$ kilograms. Dr. Richards finds and uses throughout 3360, i.e., double the real weight.

Further, the price of the kilogram of refined gold is assumed to be \$729. While such a high price for electrolytic gold might justify the high calculated interest charge, yet it is to be feared that even American dentists, who are said to prefer electrolytic gold, would not pay this price. According to recent information from Philadelphia, the Mint figure is a price of \$664 per kilogram of refined gold.

If we now substitute 1680 kilograms for 3360 and \$664 for \$729 in the calculation and if we calculate otherwise exactly as Dr. Richards does, we find the interest charge on gold stored in anodes and cathodes per kilogram of corroded gold as 28.5 cents instead of 51 cents.

But even this figure is found to be too high, if we revise the calculation further, without changing for the present anything in the assumptions. Dr. Richards obtains in 24 hours a deposit of 563.7 kilograms of pure gold, while in the same time only 304 kilograms gold are dissolved from the anodes. This gives a deficit of 259.7 kilograms of gold per day. Dr. Richards leaves it to his readers to consider the meaning of this deficit in the process.

Before we undertake to do this, it may be mentioned that the value found for the deficit is still too low. In calculating the ampere-seconds required to deposit 0.07 gram Pb, a multiplication sign, placed by mistake instead of a division sign, gives one error. Further, it is assumed that copper passes into the electrolyte as a monovalent ion, while it should be figured as a bivalent ion without any doubt. (Even if it dissolves at the anode as monovalent ion, the reaction $3\text{Cu}^+ + \text{Au}^{+++} = 3\text{Cu}^+ + \text{Au}$ will soon be active.) By making these two corrections, the daily deficit in the example becomes 285.9 kg of pure gold. That is, the deficit amounts to more than half of the 563.7 kg of gold which are to be deposited in 24 hours.

What does this mean? It means strictly that the process cannot be carried out in the way assumed in Dr. Richards' example. For it is impossible to deposit 563.7 kilograms of gold from a solution to which only 277.8 kilograms are added during the same time by solution from the anode. To render the process possible for the whole 24 hours, it is necessary to add to the electrolyte the deficit of 285.9 kilograms in some way.

This quantity of gold must be available from the beginning of the process, besides the calculated weight of the anodes, either as refined gold or in form of impure gold containing 385.9 kilograms of pure gold. This quantity must be brought into solution outside of the electrolytic tanks and must be gradually added in form of gold chloride to the electrolyte during the 24 hours of operation. This is to be repeated every day as long as the process is carried on.

It, therefore, becomes necessary to add to the interest charge, calculated before, the interest on 285.9 kilograms of pure gold. Nevertheless (under certain conditions) the interest charge for every kilogram of dissolved and deposited gold is not greater, but smaller than found before, since the \$118.60 of daily interest do not refer now to 304 kg (more correctly, 277.8), but to 563.7 kg of pure gold. The revised calculation, therefore, gives 21 cents instead of 51 cents per kilogram.

So far I have followed the methods of calculation exactly as made by Dr. Richards. But some of the data assumed by Dr. Richards I do not consider to be suitable. The impure gold anodes are assumed to have a thickness of 2 centimeters. This is well suited for copper plates, but in gold refining, if interest charge cuts a figure, it is too large, for the simple reason that, even with the high current density of 1000 amperes per square meter, a considerable part of these anodes is not dissolved by the current in 24 hours. This is, therefore, dead capital which only eats up interest.

*In an appendix to the paper the complete cost of plant for producing 5000 tons of electrolytic iron in the form of tubes, sheets and wire per year (including cost of iron under treatment) is estimated at £108,295. The cost per ton of producing electrolytic iron tubes, sheets and wire is estimated at £5 15s. 3d., hence the cost per pound 1.2 cents. In this estimate the cost of the electric kilowatt hour is apparently assumed to be somewhat like 0.5 cent. The electric power cost is, under these conditions, little less than half the total cost of operation.—Ed.

If we make the anodes thinner so that they are consumed within 24 hours to as small a rest as possible, there will be a reduction of interest charge without any appreciable increase of other items of cost. Further, if we give to the starting sheets of the cathodes a thickness of $1/6$ mm (which is quite sufficient) instead of 1 mm in Dr. Richards' example, the interest charge on the gold in the starting sheets is reduced to one-sixth.

With anodes and cathodes of such dimensions as used in practice, then with the same gold alloy, for which Dr. Richards makes the calculation, an interest charge of about 13 cents per kilogram of treated pure gold is found. It is unnecessary to give this calculation in detail, since I have already dealt with the calculation of interest in electrolytic gold refining in former articles in this journal (Vol. 11, pages 221 and 261). A small difference between the results given there and here is due to the different composition of the gold alloy to be refined.

It, therefore, follows that the high interest charge, found in Dr. Richards' example, is not inherent in the nature of the electrolytic process, but, besides some errors in calculation, it is due to the fact that the conditions of operation, assumed in this example, are unsuitable. There is an essential relation between the interest charge, found by Dr. Richards, and the thickness of plates, selected by him, and his numerical result does not represent a general disadvantage of the process in practice.

I am afraid that another erroneous impression may be obtained from the fact that among the first suppositions of Dr. Richards' calculation there is an assumption as to the current density to be used, without any explanation why this and no other current density is selected. The practical man might think that he was at liberty to choose his current density, so that he could enjoy all the advantages of as high a current density as possible. Experience would soon prove this to be a serious mistake.

If the alloy of Dr. Richards' example is treated as anode at the assumed current density of 1000 amperes per square meter, it will not be possible to continue the experiment for more than a few minutes. Awkward fumes of gaseous chlorine from the 10 tanks will soon indicate that the gold does not dissolve from the anodes; that the solutions lose their content of gold, and the voltmeter will show that the voltage is far from remaining within the moderate limits assumed in Dr. Richards' example.

The simple cause is that anodes containing 7 per cent silver and 7 per cent lead can be used only with current densities far below 1000 amperes per square meter, so that the process cannot be carried out as assumed by Dr. Richards. The refiner cannot select his current density ad libitum. The composition of the anode material, especially the content of lead and silver, determine the permissible maximum current density and, therefore, the whole arrangement of the operation, as is evident from Dr. Richards' calculation.

Before carrying out the theoretical calculation of the process, it is necessary in every case to consider what are the limitations due to the constitution of the anodes and how must the details of the process be arranged accordingly. If such a preliminary investigation is not made, the whole calculation rests on an unsafe foundation.

Finally, I will say a few words concerning the "deficit" of gold found in Dr. Richards' example. It means not only a high interest charge (this might be made up for by a higher platinum content in the gold), but the deficit leads with necessity to the bankruptcy of the process. Although Dr. Richards does not say so, it is easy to arrive at this conclusion.

We have seen that to cover the daily gold deficit in Dr. Richards' example, it is necessary to change 285.9 kilograms of gold daily (either as pure gold or as a gold alloy) into gold chloride outside of the electrolytic tanks. This will in general be done by dissolving the stated quantity of gold or gold alloy in aqua regia. If the same gold material is used for making this additional solution as is employed for making the anodes,

one has the advantage to treat about twice as much material as would be treated in the same time by electrolysis alone. But for the one-half of the material which is dissolved in aqua regia, we lose the essential advantage of the electrolytic refining process, which depends on the solution of the gold without the use of hydrochloric acid and without the development of gaseous chlorine. The cost, thus increased, is further increased by the additional work which is necessarily required.

The chloride solution thus produced must be freed from dissolved silver chloride and must then be concentrated to such a degree that it is possible to add it to the tanks. That this involves considerable difficulties is evident from the following calculation.

The object is to add 285.9 kilograms of gold in such a way to the tanks, that during the 24 hours of operation the original volume is not essentially increased. The 10 tanks of Dr. Richards contain originally together 600 liters of solution, and this volume must remain practically unchanged, while during the 24 hours a solution containing 285.9 kilograms of pure gold is added. If this gold solution is concentrated to such a degree that it contains 400 grams of pure gold per liter, it is necessary to add 715 liters of the strong additional solution to the 600 liters of original solution without changing the level of the solution. Evidently this would be possible only if during the 24 hours 715 liters of water would be removed from the tanks in form of steam. In view of the low temperature in the tanks and the small surface of evaporation, this evaporation could not be carried out in the tanks themselves, but would have to be done outside. This means another complication.

In view of this situation the older methods of refining would be preferable to the electrolytic process, if carried out as assumed with so much additional chemical operations which are rendered necessary by the gold deficit. Indeed, we have as a correlate to the gold deficit a quick increase of other impurities, and this means that we lose another advantage of the electrolytic process, when properly carried out, namely, the possibility of using the same electrolyte many times over and over again.

By treating the anode material of Dr. Richards electrolytically, 151 kilograms of impurities would pass into solution during 24 hours from the anodes. Another 155 kilograms of impurities would get into the solution as the result of adding at intervals new solution (made as described) to keep up the gold content. Hence, after 24 hours of electrolysis the 600 liters in the 10 tanks would contain, besides the gold solution, 306 kilograms of impurities or 598 kilograms of foreign chlorides in excess above those contained originally in the tanks.

It is unnecessary to say that it would be impossible to electrolyse again this solution, which would be more a mash than a liquid. Daily renewal of the electrolyte, daily treatment of the electrolyte left from the day before, are therefore other consequences of the deficit of gold. This means bankruptcy of the process.

I am not afraid that Dr. Richards might reply: "You say so." For it is evident that the serious disadvantages following from his calculation are not due to the electrolytic process of gold refining, but to the composition of the anode material, selected for the example. Not the electrolytic process is proven to be practically impossible by the calculation, but its application to an alloy of 60 per cent gold, 7 per cent silver and 33 per cent of other soluble metals. But to prove this it would not have been necessary to make the long calculation.

It would have been sufficient to make a preliminary investigation as to what alloys are suitable for the electrolytic refining process. Anybody familiar with the process would at once exclude all alloys containing so many foreign metals that the electrolyte loses all its contents of gold in half the time of operation and becomes simultaneously loaded with other metals to an extent as to be unsuitable for further use.

I do not overlook that the object of Dr. Richards' example is rather to show the general method by which to make such

theoretical calculations, and that only incidentally an alloy of unsuitable composition has been the subject of his calculation. But I doubt whether a practical man can make such calculations to his advantage without taking into account among other things the following points which I believe must be emphasized:

First, before employing the electrolytic gold refining process and before calculating its requirements and results, it is necessary to make a preliminary investigation whether the available raw gold alloy is suitable for electrolytic treatment, according to its composition.

Secondly, if the raw gold alloy is found to be suitable, it is necessary to decide on the conditions of operation, especially on the current density to be used, according to the composition of the anode material. This cannot be chosen at will, but the selection must be based on experience or theory (if there is a theory which answers this question).

Thirdly, if interest is to be charged for the gold, it is necessary and easy to modify the conditions of operation in such a way that the interest charge becomes a minimum.

Hamburg, Germany, August, 1908.

[Dr. Richards, to whom a copy of this article was sent, "wishes to express himself as being very well satisfied to have made the possible errors charged against him by Dr. Wohlwill in the above article, seeing that the present net result has been to clarify the subject for our readers and to have drawn from Dr. Wohlwill a lucid and masterly presentation of the inner facts and considerations concerned in the electrolytic refining of gold. Florence, Italy, Sept. 20, 1908."]

A Swiss Electric Furnace Steel Plant.

The machinery firm of Oehler & Co., at Aarau, Switzerland, are makers of steel and cast-iron machinery parts. They have a crucible steel plant of the ordinary kind, which has been replaced since August 1 of this year by a Girod arc furnace, with the most satisfactory results. An electric steel furnace plant of the induction type was started two years ago in Gurtellen, Switzerland, but the company has gone out of business. An electric furnace steel plant is in course of erection at Schaffhausen, Switzerland, based on the experiments of G. Fischer, and will probably be in operation before the close of 1908. Oehler & Co. claim, however, to have the credit of being the first successful electric steel foundry in Switzerland.

The company in question has acquired the patent rights to the Girod furnace in Switzerland. The Société Anonyme Electrometallurgique in Ugine (Savoy), of which Mr. Paul Girod is director, has at present four furnaces of two to eight tons capacity in operation, making ferro-alloys or ordinary fine steel. This company has 26,000 horsepower at its Savoy works.

The furnace erected for Oehler & Co. has a capacity of two tons, and requires 400 horse-power. Similar plants have been erected for the John Cockerill Society, in Belgium, for steel for military purposes; for Stoss in Stuttgart (Southern Germany), for fine steel castings, and for the Ternitz Steel Works in Austria, for machinery steel. The success of the furnace, and the commercial advantages of the process appear now to be beyond question.

In the Swiss plant at Aarau, the power is supplied by the Aarau City Electric Works, which utilizes a fall of the Aare, and has 3,000 to 4,000 horse-power at its disposal. It distributes power at 2,000 volts two-phase current, and sells it at the following prices:

55 centimes = 11	cents per kilowatt hour for lighting purposes
27 " = 5.4	" " " " " " " " " " " "
3 to 4 " = 0.6	" " " " " " " " " " " "
	0.8 " " " " " " " " " " " "

The smelting rate is, therefore, taking the higher figure, 19.2 cents per kw.-day, of \$70 per kw.-year. Of course, the bill for energy consumption is based on the actual number of kw.-hours used, determined by meter.

The 2,000-volt two-phase current system supplies at the

Oehler works a motor of 450 horse-power, running at 560 revolutions, and coupled direct to a single-phase alternator, giving 4,600 to 5,000 amperes, single-phase current at 65 to 75 volts, the frequency being 37.4 periods per second. The use of the motor generator instead of a static transformer is interesting—without necessary.*

Twelve heavy copper cables, each 20 millimeters in diameter, and composed of 12 copper wires twisted together, carry the current 10 meters to the furnace. The voltage drop is 2.5 volts from the machine to furnace. The general features of the Girod furnace were described on page 428 of our last issue. The furnace is 2 meters inside diameter, 0.5 meter high, inside, and is electrically tipped and regulated. The automatic electrode regulator, by H. Cuenod, of Geneva, raises and lowers the electrode passing through the roof, so as to keep the current

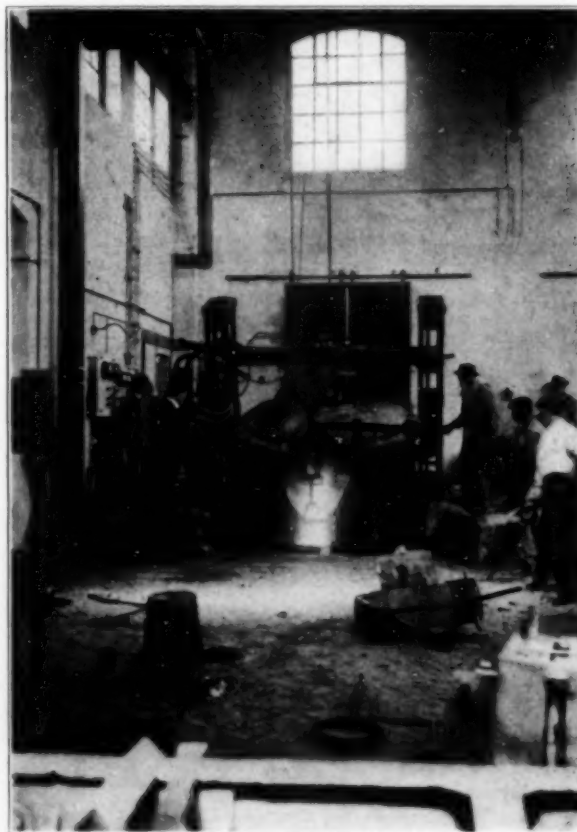


FIG. 1.—GIROD STEEL FURNACE AT OEHLER WORKS.

at the desired strength. The lining is stamped-in Styrian magnesite. The electrode is 350 mm. square by 1,500 mm. long, all in one piece. It weighs 200 kilograms at starting, and lasts sometimes 10 charges, but on the average 5 to 7. They come from the Girod works at Ugine (Savoy), and cost \$40 each.

In operation, charging takes about one hour, and when the current is turned on it takes 5 hours more, until the charge of 1,500 kilos is ready for pouring, with a current of 5,500 amperes at an average of 55 volts. At present two heats a day are run, but three could be easily obtained if the furnace were run continuously. A typical charge is:

*It is essentially impossible to transform from a balanced polyphase system to single phase by means of stationary transformers. As in one case we have a constant power flow, in the other case an intermittent one (see, for instance, Steinmetz's Alternating-Current Phenomena), the transforming apparatus must be able to store energy in a moment and give it off in another. That means, we must have revolving machinery. It seems not superfluous to emphasize this here, since attempts continue to be made and even to be patented to run a single-phase furnace from a polyphase system without unbalancing the latter.

Pig iron	265 kg.
Turnings	150 kg.
Scrap iron and steel.....	460 kg.
Return scrap	425 kg.
Lime	60 kg.

Besides these, varying quantities of ferro-manganese, ferro-silicon and aluminium are used, according to the needs of the charge.

A typical analysis of the steel, which is run into small castings, is:

Carbon	0.53 per cent.
Silicon	0.474 per cent.
Manganese	0.275 per cent.
Sulphur	0.017 per cent.
Phosphorus	Trace

Ninety-eight per cent of all castings are good, even in the case of the smallest and thinnest castings, and their long experience in making crucible-steel castings enables this firm to obtain castings as clear as ordinary foundry castings. The average tensile strength obtained is 55 to 65 kilograms per square millimeter (80 to 90,000 pounds per square inch), with elongation 5 to 10 per cent.

It is calculated that the electrical part of the plant has an

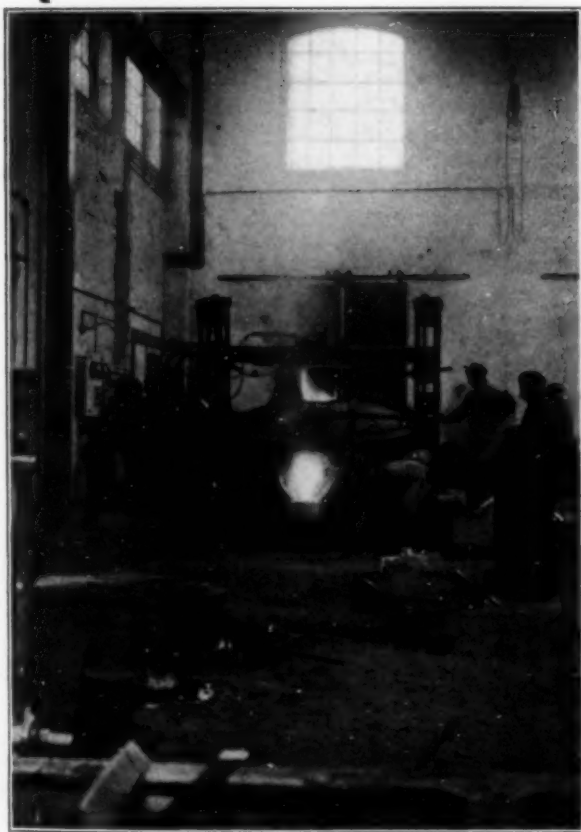


FIG. 2.—GIROD STEEL FURNACE AT OEHLER WORKS.

efficiency of 75 to 80 per cent; that is, that 75 to 80 per cent of the energy of the primary current appears as heat in the furnace. A rather approximate estimate of the calorific efficiency of the furnace itself, shows about 50 per cent of the energy of the current converted into useful heat.

The photographs show two views of the furnace in operation and about to be tapped, one into a hand ladle, the other into a crane-supported ladle. For the photographs and the information we are indebted to the kindness of Messrs. Oehler & Co.

Technical Thermometry.

By J. H. HART, PH. D.

During the last few years great progress has been made in the science of thermometry, and manufacturers now realize the assistance that the physicist can give them in measuring temperatures which are of vital importance to them. In an immense number of industrial operations accurate temperature measurements are of the first importance.

The element of chance, so conspicuous and so costly in many operations, is nothing less than the element of ignorance, and progressive manufacturers in every phase of production are beginning to realize that where knowledge is obtainable guesswork is too expensive a system to tolerate. In many processes where the judgment of the temperature was previously by the eye of the workman, or in some equally vague or deceptive way, thermometers are now in regular use, saving serious loss from spoil work and material and effecting other considerable economies.

As an example of the widely varied practical application of the various electrical and radiation thermometers and pyrometers, the following may be mentioned: Annealing furnaces, boilers and superheaters, explosive sheds, porcelain kilns, hardening furnaces, brick kilns, hot blast mains, glass furnaces, casting and molding operations and many applications of ordinary temperature developments other than the extremely high or cold, and involving the active determination of temperatures at widely separated distances under variable mechanical conditions at one point at the same time. Under this head come large cold storage warehouses, with the accurate reading of thermometers in all the various boxes or cold storage rooms; breweries, chemical works, bakeries, hospitals, etc.

It is more especially the object here to consider the various types of thermometers available for utilization in molding and casting of the different metals, the principles back of these thermometers, their various advantages and disadvantages and their method of installation and cost, with operation and deterioration factors.

There are four different types of thermometers or pyrometers available for the measurement of comparatively high temperatures, and by high temperatures is meant those existing between slightly below red heat up to and including the melting point of iron. These types consist of electrical and radiation and absorption thermometers, the electrical thermometers being divided into two types, depending on the variation of electrical resistance with temperature and the production of a thermoelectric current, respectively.

The resistance thermometer consists essentially of a glass porcelain or platinum tube, enclosing a mica framework, around which is wound a platinum wire. These wires go out and can extend through flexible metallic tubing or otherwise to the recording devices, or to any measuring instrument situated at any point where the measurement is desired. The variation of the resistance of this wire with temperature for electric current is well known, and its resistance is measured by means of the Wheatstone bridge, an ordinary device for measuring resistance.

The principle back of the Wheatstone bridge is a comparatively simple one in electricity, but involves a number of operating details for the measurement of resistances under ordinary circumstances. However, its development has been such, in conjunction with the platinum thermometer, that the electrical recording device reads directly any temperature reading without the necessity of much adjustment and that of a purely mechanical character.

These porcelain tubes have four lead wires extending into them, two of these carrying the resistance wire, or measuring device, and the other merely serving to eliminate the error due to the heating of the leads and the variation in resistance of these with temperature. These tubes can be made of any length and have handles attached so that they can be inserted through

a suitable hole in the melting furnace, or into a pot of melted metal, and kept there constantly, recording the temperature until that desired for casting purposes is attained. They are, to all practical purposes, thermometers which are stuck into anything the temperature of which may be desired.

They can also be installed permanently at fixed points and can record the temperature at any time, or the temperature variation with time, by means of a recording drum or a recording disk.

These resistance thermometers have a wide range, from the lowest temperatures to 1200° C. or 2200° F. They can be placed in inaccessible positions and read from a considerable distance. They are extremely sensitive and respond quickly to changes in temperature. They can give direct readings of temperature, requiring no correction. They can furnish a visible record of temperatures varying from 10° or 20°, and the temperature can be read off without disturbing the records. By means of a switchboard a single indicator or recorder can be connected as desired to any number of thermometers. They represent probably the best type of thermometer, when action and reliability is considered, for all smelting, annealing and casting purposes.

The thermo-electric thermometers have many of the above advantages and, with special precautions, are as accurate as resistance thermometers. But they can be used up to much higher temperatures than resistance thermometers, namely, 1600° C. or 3000° F., and the temperature of a small quantity of a substance can be more readily measured. They are less costly to replace, and in their industrial form no battery is required, since they generate their own operating current. In conjunction with the millivoltmeter, they give direct readings of temperature, requiring no correction under ordinary temperature conditions.

The principle upon which they operate is based upon the fact that two different metals when in contact at two points generate an electric current around the system if one junction is hotter than the other. This phenomenon is known as thermo-electricity, and the average thermo-electric thermometer has its leading device or millivoltmeter so calibrated that they read accurate temperatures if the cold junction is kept at a constant temperature.

Some of these devices on the market use metals such that the ordinary climatic variations of temperature at the cold junctions require corrections which are negligible, and some types using less satisfactory materials for the production of the thermal electricity have a cold junction compensator, consisting of a mercury bulb, which by its expansion diminishes the resistance in the circuit and thus increases the action of the current in the millivoltmeter or diminishes it, as required. A suitable recorder can be used with this, and records from a number of thermometers can be obtained simultaneously on the same drum.

The radiation thermometers can be used from temperatures of about 500° C., or just below a red heat, up to the highest temperatures known. Since no part of this instrument is heated above 80° C., the life of this pyrometer is practically unlimited, whereas the deterioration of the other types, or of portions of the same, may be quite pronounced, since the thermometer part itself attains the temperature to be measured.

The radiation pyrometers, in conjunction with an electrical measuring instrument, give the direct readings of temperature, requiring no correction. They may or may not require a battery for their operation, depending upon whether they utilize the resistance or thermo-electricity principle in their interior, but in general, in the types on the market, no battery is required.

This thermometer is based upon the principle of the variation of the amount of radiation with temperature. According to what is known as Stefan's law, the amount of radiation given out from a body varies as the fourth power of the absolute temperature, and this law is exact as far as is known to science to-day. The thermometer consists of simply a telescope, which is sighted upon the body whose temperature is to be measured

and which reflects the radiation by means of a convex mirror on to a small thermo-electric junction, or small resistance wire, which becomes hot under the action of the radiation.

It is a remarkable condition that the relative position of this pyrometer with respect to a hot body whose temperature is to be measured can vary within wide limits without affecting the accuracy of the measurement. It has been found, for example, that the reading obtained for the temperature of a stream of molten steel was precisely the same 1200° C., whether the instrument was set up 3 ft. or 60 ft. away. The entire outfit consists of a telescope and a galvanometer.

The thermal couple in the interior of the telescope is heated by reflection from the mirror, and there are a comparatively few simple rules for its operation. Hence, the temperature can be obtained by simply looking at the metal through this telescope and taking the reading. The instrument is of special value for taking such high temperatures as those of molten steel, glass furnaces, brick kilns and electrical furnaces.

Its great flexibility and the readiness with which it is sighted enables it to be used for taking the temperature of metal in crucible just before pouring, thus ensuring correct casting temperatures, a point which is now known to be of special importance in the case of steel castings. It holds equally well for castings of all materials, since the temperature at which rapid cooling commences very greatly affects the microscopic structure of almost all alloys.

The Fery absorption pyrometer utilizes the same principle to the extent that the temperature measurement is based upon Stefan's law. A telescope is used and sighted upon the object whose temperature is desired. A small wedge-shaped, partially opaque prism is gradually inserted until the radiation from this substance is identical with that from a standard lamp, and the readings can be taken from the device operating the absorption wedge. It is of special importance in taking temperatures of very small bodies such as incandescent lamp films, high-temperature chemical reactions and laboratory work generally.

Of these devices the resistance thermometer is undoubtedly the most accurate and possesses the greatest sensibility. Small variations in temperature can be more readily measured, but the device is expensive and deteriorates with much greater rapidity than the other types, with the exception of the thermo-electric system. This latter, on the other hand, can be replaced readily and at much smaller expense.

However, absolute temperatures, or very accurate ones, are not especially essential in most industrial developments. The limitation of temperature variation in casting and melting of from 30° to 40° will result in a marked improvement in the character and uniformity of the product, since these temperature variations have formerly been of unknown amount and character.

A further limitation of the temperature within more restricted limits, while undoubtedly resulting in increased uniformity of product, are accomplished only by greater effort on the part of the operator, since the temperature varies considerably, under ordinary operating conditions, and the increased efficiency of production which results is not warranted by the outlay required for its maintenance. Thus the special advantages of the resistance thermometer are not essential for industrial progress. The thermo-electric and the Fery radiation thermometers are not only cheaper and easier to operate, but possess a much lower deterioration factor and as a general thing a much lower first cost. The absorption pyrometer as mentioned, while available, requires greater detail in its operation, with less accuracy in its reading than the other types. It is especially used, as has been said, in the determination of temperatures of very small bodies which could not otherwise be determined by any of the other types.

The radiation pyrometer possesses possibilities for its adaptation which will undoubtedly make it a strong competitor of the thermo-electric type. It is in reality a thermo-electric type, so

constructed that the junction does not enter the flame at all, and no part of the instrument becomes hotter than about 80° C. Its great range in adaptability, since it is essentially a portable device and can be carried from one part of the foundry to the other without having a flexible tubing connected with the thermometer for insertion, gives it a distinct advantage. However, in the pouring of molten metal its temperatures are not apt to be as exact as that involved in the insertion type, since the surface temperatures are always considerably less than that existing in the interior.

Some one of these types, whether of the practical or laboratory pattern, should be installed in every foundry and metal laboratory. Its utilization in research work and in the preparation of alloys and the detection of impurities compares very favorably with that of the most approved chemical analysis. In the preparation and examination of the new alloys, with the determination of heats of recalcence, its efficiency is unquestioned, and it is essentially an instrument of research in metallic investigation as important as that of any other device.

In the present state of foundry practice conditions are such that all save one can be held, by suitable care, in good control. That one condition is the temperature of the metal as it enters the mold. In no experiment has the influence of varying casting temperature failed to show, and none of the forms of after treatment such as annealing, rolling, etc., have brought the metal to the same uniform quality that the proper selection of temperature by this means has been able to accomplish.

Roasting Furnaces.

By OSKAR NAGEL, PH. D.

The usual roasting furnaces may be divided into the following general types: The hand-stirred reverberatory; the reverberatory with continuous discharge; the revolving cylinder with intermittent discharge; the revolving cylinder having continuous discharge; circular multiple-hearth shaft furnaces; muffle furnaces.

With these furnaces wood, coal, gas or oil can be used as fuel and all are intended for roasting crushed ore.

The ordinary hand-stirred reverberatory roasting furnace consists of a continuous hearth, covered by a low arch and having a fire-box at one end and a flue at the other. A furnace of this kind was illustrated in the February issue.

This furnace can often be economically built of stone, up to the half level, the rest of the structure being constructed of brick, the entire mass being bound together with T-rails or I-beams and wrought-iron tier rods. The hearth should be of sufficient area to suit the charge of the ore and tonnage required. The Allis-Chalmers Company builds them in sizes ranging from 7 by 10 feet to 17 by 72 feet.

A good example for a reverberatory with continuous discharge is the Brown roasting furnace, made by the Allis-Chalmers Company, and shown in Fig. 1. In its most improved form it is a single-hearth reverberatory, with an interior slotted wall on each side of the hearth, covered with a low arch. This roaster is made straight or round in shape, to suit local conditions. Fire-boxes, in number and position to suit the length of the furnace and the character of the ore, are provided. This furnace, in which stirring is done mechanically, is generally provided with an automatic ore feeder.

The Bruckner roaster, which consists of a revolving cylinder with intermittent discharge, was shown in the February issue. It is generally lined with fire brick, the cylinder resting on friction rollers and revolving between a fire-box and a flue.

The flame from the fire-box passes directly through the cylinder, and thence mixed with the gases from the ore, into a dust chamber. The cylinder is provided with manholes for receiving and discharging the ore, the latter being roasted in charges of several tons. The advantages of this type of roaster are that the charge of ore may be retained in the furnace as long as required, the heat can be nicely adjusted and the roasting can be completely and economically performed.

A circular multiple-hearth shaft furnace is the Stetefeldt roaster. It consists of a vertical brick shaft about 25 ft. high, having a fire-box nearer the bottom and a flue opening nearer the top; by means of a screw feeder, worked automatically, pulverized ore is continually sifted into the shaft, and, in falling through the heated air, which takes but a few seconds, it is roasted. There is also a fire-box placed at the bottom of the descending flue for roasting the flue dust.

The construction of the Wethey roasting furnace, made by the Allis-Chalmers Co., is easily understood from Figs. 2 and 3.

The White-Howell roasting furnace, built by the Allis-Chalmers Company, and shown in Fig. 4, belongs to the type of revolving cylinder with continuous discharge.

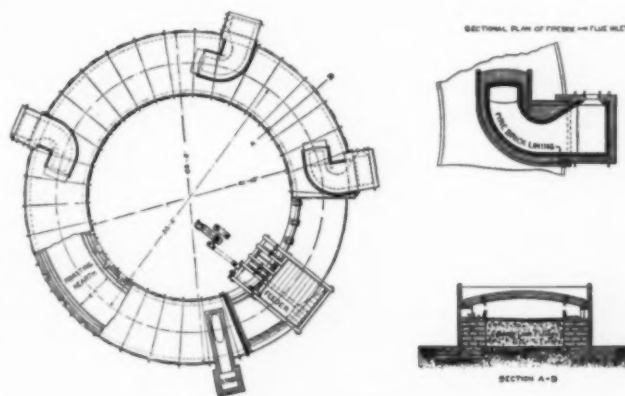


FIG. 1.—BROWN ROASTING FURNACE.

Roasting furnaces with a central shaft, with a number of circular shelves placed at right angles to it and with mechanical stirrers, are the Herreshoff roaster and the McDougall roaster. The latter, which is built by the Allis-Chalmers Company, is illustrated in Fig. 5. It is a vertical iron cylinder lined with brick; in it are 5 or 6 horizontal hearths constructed of brick. Through the center of the furnace and extending from top to bottom is a hollow water-cooled shaft. Directly connected to



FIG. 2.—WETHEY ROASTING FURNACE.

the latter are hollow water-cooled horizontal arms, and to these are attached removable and adjustable rables.

The ore or matte, preferably reduced to $\frac{3}{8}$ in. or finer, is automatically fed into the uppermost hearth, and by the action of the rables it is carried toward the center, where it drops through an annular opening onto the next hearth. On the second hearth the rables feed the material gradually outward until it drops through marginal openings in the hearth onto the third hearth. The rables on the third hearth move the mate-

rial to the center, where it is discharged onto the next hearth, and so on throughout the furnace until it is delivered into a receiving hopper. The hollow central shaft and central arms of this type of furnace are provided with a water-cooling system, arranged for the circulation of water through the whole interior of same.

This furnace is suitable for roasting ores, concentrates of matte, which contain sufficient sulphur to roast of themselves, not requiring external heat. Ores carrying from 25 to 35 per cent sulphur can be roasted down to from 5 to 7 per cent of sulphur by their own heat alone.

For starting the roaster and for keeping it hot when it is shut down temporarily a circular fire-box is furnished, which is used in connection with two roasters. The usual construction is

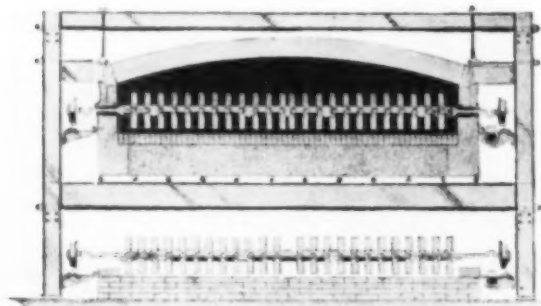


FIG. 3.—WETHEY ROASTING FURNACE.

to put in a fire-box for each two furnaces, simply for keeping up the heat should a shut down be necessary. For roasting non-combustible matter the fire-box is incorporated in the furnace, being placed under the lower hearth.

This roaster is suitable for roasting sulphide ores, the fumes from which are to be converted into a sulphuric acid. It is also in demand for roasting ores and mattes for subsequent smelting. The furnace, which is simple in construction, occupies but little space. The power required is from $1\frac{1}{2}$ to 2 hp. The speed with which the arms and rabblers revolve is determined by the degree of roasting required in the furnace and the

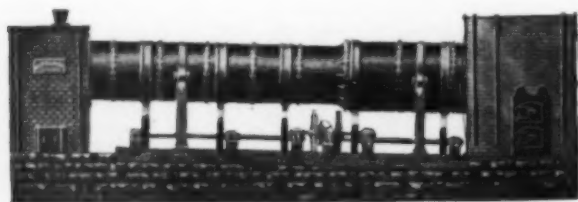


FIG. 4.—WHITE-HOWELL ROASTING FURNACE.

character of the ore. At Anaconda the shaft revolves once in $1\frac{1}{4}$ minutes.

In the Herreshoff roaster, built by the Nichols Copper Company (Fig. 6), two arms are attached to the shaft over each shelf, placed in opposite directions, having teeth or rakes so disposed on the first shelf that the roasting material is plowed from the shaft outward and delivered through openings at the outer edge of the shelf. As the ore drops on the shelf below the plows are so placed that the material is turned over and over, finally discharging through a large opening around the shaft. The area of this opening is sufficient for the gas that passes through it. The same is true of the openings at the outer edge of the shelf above.

The material after being plowed very slowly over five shelves, finally discharges through two outlets at the outer edge of the bottom shelf. The furnace has a very large vertical shaft, 14 in. in diameter, made hollow, so that a large quantity of air is drawn up through it; this amount being increased by the intro-

duction of a sheet iron stack extended above the top of the furnace.

Between the shelves there are cross-channels passing directly through the shaft at right angles. These channels are about 4

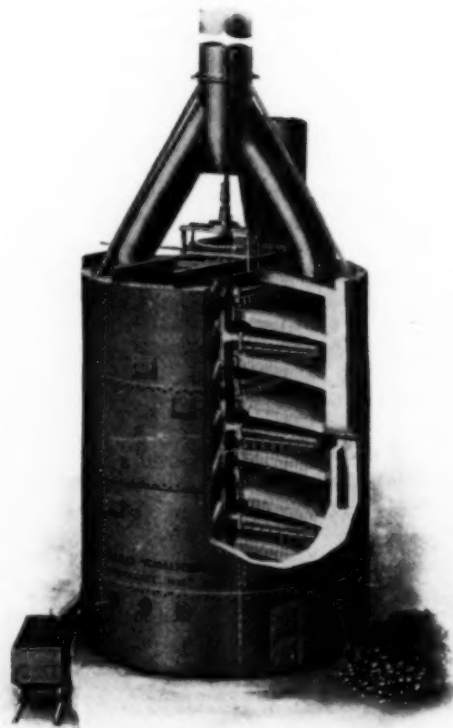


FIG. 5.—MC DOUGALL ROASTING FURNACE.

in. wide and 5 in. high and allow ample space around them for the passage of the ascending air. Into these channels or sockets the arms are inserted. In the top of each channel, at the center

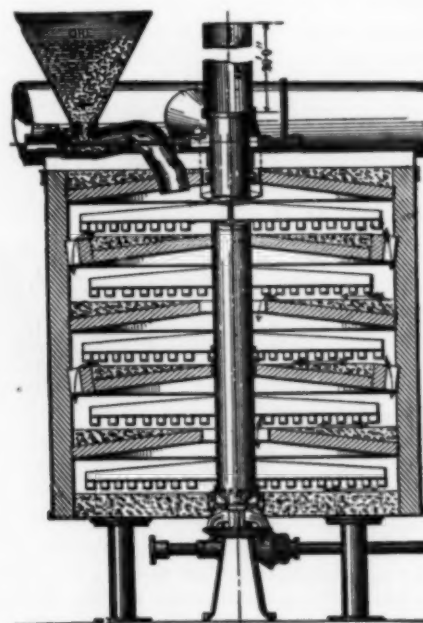


FIG. 6.—HERRESHOFF FURNACE.

of the vertical shaft, is a pocket running across the channel; into this a rib at the inner and top edge of the arm locks when the arm is forced into its proper position.

The weight of the arm always keeps it properly locked in the channel. By raising the outer end of the arm about 3 in. the top edge of the rib is brought below the pocket, and the arm can be easily pulled out. Practice has shown that these arms, weighing 100 lb., can be unlocked and removed from the furnace, and new ones put in and locked into place in about one minute.

Each furnace requires from one-tenth to one-quarter horsepower. The labor required is very small. At Butte 36 of these furnaces have been running for several years. For the control of their work one man only at each shift is required. The principal repair is due to the corroding or burning out of the arms. About six arms per year have to be renewed.

The ore is fed automatically, by means of a plunger that is

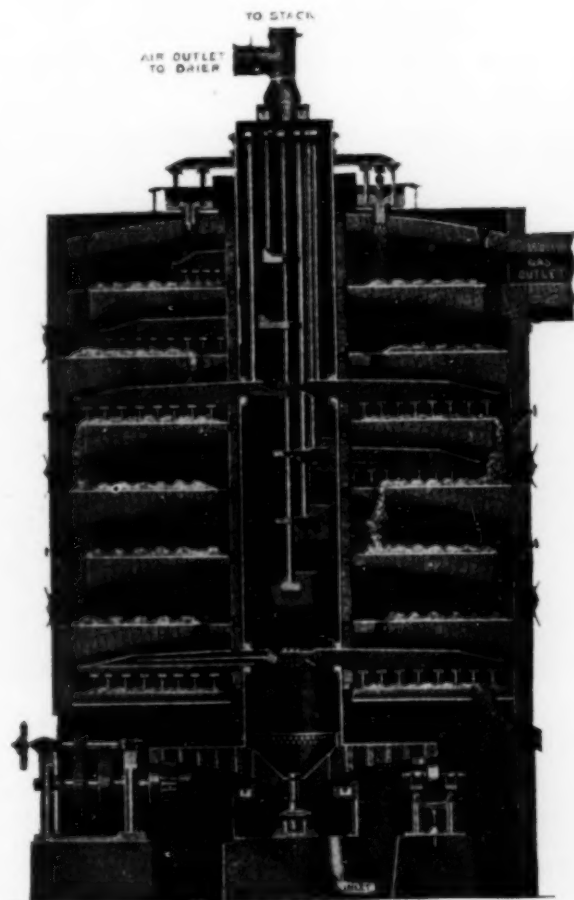


FIG. 7.—WEDGE SEVEN-FLOOR PYRITES ROASTER.

moved back and forth in a horizontal cylinder. When going toward the central shaft the ore is pushed forward and discharged down the curved pipe on the top shelf. When the plunger is pushed back, away from the central shaft, the fine ore descends and fills the vacant space. The mechanical device for the performance of this backward and forward movement is very simple. The central shaft revolves one revolution in two minutes, the plunger making two strokes in the same time. The usual amount of 44 per cent ore roasted in such a furnace is 7000 lb. The roasted ore contains from 2 to 3 per cent sulphur.

The central shaft, presenting a large cooling surface, modifies somewhat the temperature of the whole furnace. This is a decided benefit. That portion of the arm where greatest strength is required is maintained below a red heat, as well as the shaft itself. The arms are hollow and of rectangular cross-section, and made of a composition, which stands the high heat satisfactorily.

Fig. 7 shows the Wedge roasting furnace, which is built by the Pennsylvania Salt Company. It is provided with a heavy shell and with vertical seams double riveted. The shaft is protected with bricks on the outside. The arms are arranged to be cooled either with air or with water, according to the character of the material to be roasted. The arms last a very long time. The individual stirring blades are removable and, if one breaks, it can easily be replaced.

A Rotatable Zinc Furnace.

BY GEORGE A. WETTENGEL.

The ordinary method of charging a zinc furnace is highly troublesome. Similarly the cleaning out of the red-hot retorts by means of water which turns to steam and blows out the residue is injurious to the retorts.

The following is a description of a furnace which does away with the processes of hand charging and blowing out:

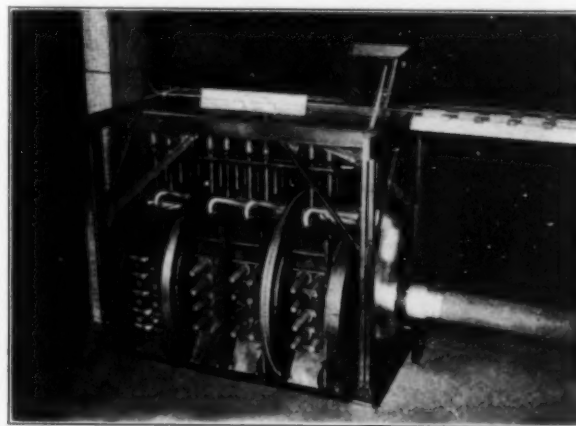


FIG. 1.—FRONT VIEW OF ZINC FURNACE IN OPERATING POSITION.

Fig. 1 is a front view of furnace in operating position. Fig. 2 shows the furnace in the charging position. Fig. 3 is a section through the furnace.

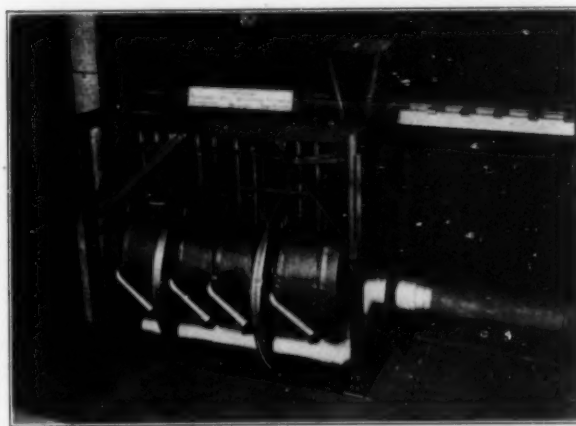


FIG. 2.—FURNACE IN CHARGING POSITION.

The furnace consists of a steel shell, with two tires supported on wheels. One tire has a gear attached, engaging a worm by which the furnace can be rotated to any desired position. The inside of the shell is lined with tile, with suitable shelves for supporting the retorts. The gas and air pipes are attached to and rotate with the furnace. The burners are placed in the back, top and bottom. Above the furnace is the charging floor, containing hoppers, each just large enough to charge one retort, with shut-off slides and telescopic spouts that are lowered to

the top of the retorts so that all the charge goes into the retorts. Below the furnace are hoppers for the residue.

The charging mixture is dumped onto the charging floor, each hopper filled, and the furnace is rotated upward so that the retorts are vertical and their open ends in line with the hopper spouts. These are now lowered, and slides opened, whereupon the charge falls by gravity into all the retorts simultaneously.

Then the furnace is rotated downward so that the retorts are now in a horizontal or any position which may be desired for the smelting operation. The condensers are put on, loamed, stuffed and vented. After the zinc is all taken out of the ore the condensers are removed and the furnace again rotated so that the retorts are again vertical, but have now their open ends downward. The residue then falls out by gravity into hoppers under the furnace.



FIG. 3.—SECTION THROUGH FURNACE.

The furnace is then rotated again so as to bring the retorts into a horizontal position and is then cleaned of loam and any remaining residue and recharged as before. But instead of rotating it to the position it occupied before, it is now rotated with the open end of the retorts pointing the opposite way. This inverts the retorts so that the bottom of each is used as the top and vice versa. This brings the slag uppermost in the retorts, so that it will melt and drip down on the smelting charge and go out into the pit on the next discharge.

This inverting of the retorts makes them practically self-cleaning, almost entirely avoids scraping, and doubles their life by using two sides. It keeps them practically straight. The method avoids the present danger of cracking of the retorts and of the slag eating holes clear through them, and it also avoids the injury to the red-hot retorts by blowing out with water.

Transmutation of Elements.—About a year ago Ramsay announced that he had observed the production of alkaline salts and lithium in solutions of copper salts, which had been submitted to the action of radium emanation. This suggested that a transmutation of elements had actually been observed. A repetition of these experiments with utmost care by Mrs. Curie and Miss Gleditsch, recorded in a recent issue of *Comptes Rendus*, has now given a negative result.

Roehling-Rodenhauser Induction Furnace for Three-Phase Currents.

An interesting novel development of the Roehling-Rodenhauser modification of the induction furnace (which was described in detail in our January issue, page 10 of the present volume), is described by Prof. B. NEUMANN in *Stahl und Eisen*, Aug. 12 and 19. The chief novel feature is that the furnace is operated by three-phase currents. A news item of considerable interest is the statement that in this furnace more than 1000 tons of steel rails have been made and sold to German railroads.

The original induction furnace required special electric generators because the requirement of a fairly satisfactory power factor* necessitated the use of a lower frequency than is used for lighting or power purposes in general. For the Kjellin furnace, with a charge of 500 kg, a frequency of 25 had to be used; for a 1500-kg furnace the frequency had to be reduced still further to 15.

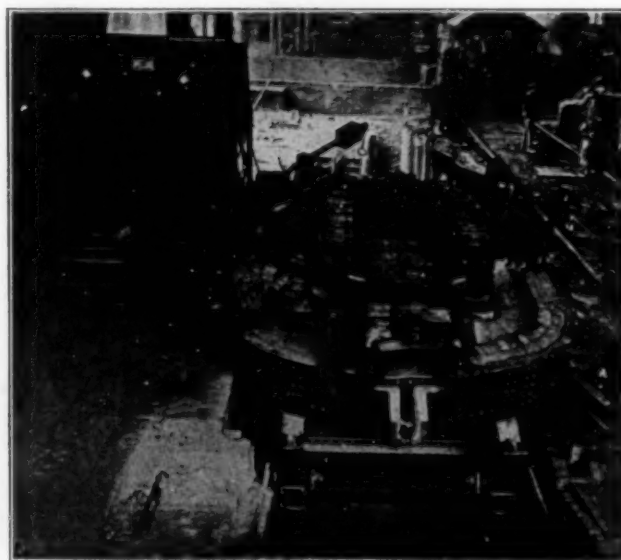


FIG. 1.—THREE-PHASE ROEHLING-RODENHAUSER INDUCTION FURNACE.

With the single-phase Roehling-Rodenhauser furnace, as described in our January issue, the power factor was already so far improved that 700-kg furnaces could be operated at 50 periods and 3-ton furnaces at 25 periods. But they still required expensive generators. This was a great disadvantage, especially with small installations.

With the new three-phase furnace this problem has been completely solved. The new 15-ton Roehling-Rodenhauser furnace is operated with currents of a frequency of 50 periods and is directly connected to the ordinary three-phase supply network of the Roehling steel works. Three-phase furnaces are now built for charges up to three tons for operation from a 50-period system, while with a frequency of 25 it is possible to increase the charge to 8 or 10 tons. The advantage of the three-phase furnace is chiefly due to the possibility of using standard three-phase generators, which do not demand an increased price.

Fig. 1 is an external view of a 1.5-ton three-phase furnace. Figs. 2, 3, 4 show sections. In its design the endeavor has been to approach as much as possible that of the open-hearth furnace.

A is the hearth; it is $\frac{1}{2}$ m wide and $1\frac{1}{2}$ m long. The three transformer cores are surrounded by the heating channels R. At the places where two such channels R enter into the main hearth A, the "pole-plates" (the special electrodes which are

*The ratio of watts to volt-amperes. The reason why it is important to have a high power-factor is explained in an editorial note in this issue.

the characteristic feature of the Roechling-Rodenhauser design) are provided. They are embedded in the furnace walls and between the pole-plates and the fused charge there is a refractory wall which is a good electric conductor when hot and then transmits the electric current to the charge.

Each of the three transformer cores is provided with a primary winding. Above each primary winding a secondary

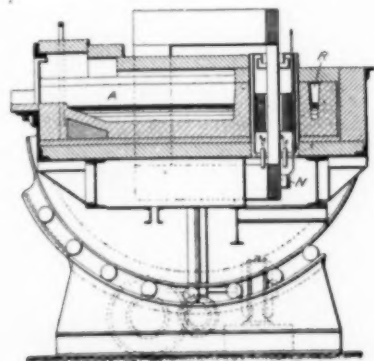


FIG. 2.—VERTICAL SECTION.

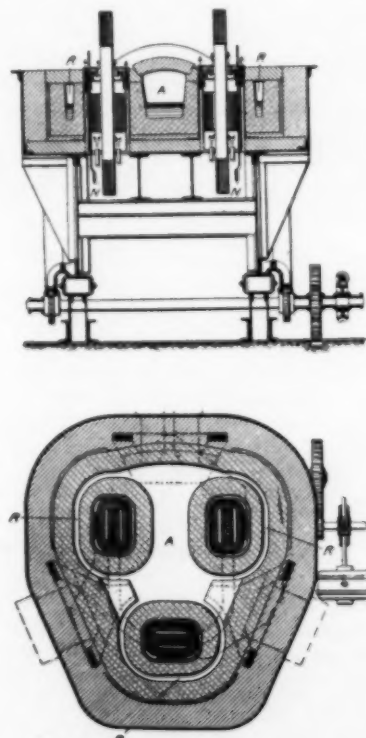
winding is also provided. While one end of the latter is connected to the busbar *N*, the other ends of the three windings are connected to the three "pole-plates." The furnace is built as a tilting furnace.

Concerning the metallurgical procedure, especially the removal of sulphur and phosphorus, the report contains nothing new, and the reader may be referred to the article on page 406 of our October issue.

A peculiar feature of the three-phase furnace is the rotation of the charge, due to the presence of a rotary field as in an induction motor. This means an excellent automatic circulation.

Some figures of analyses of samples taken from different places in the furnace are given to show the great regularity of the product in the manufacture of alloy steels.

For the production of steel rails, the electric steel is claimed to be superior to the open-hearth steel with respect to greater density and homogeneity. The open-hearth steel is first blown in the converter and then subjected to a brief refining process in the electric furnace, where the steel is allowed to stand and give off its gases.



FIGS. 3 AND 4.—VERTICAL AND HORIZONTAL SECTION.

Concerning power consumption, if the charge is introduced in liquid form, it is stated that the production of steel "of better open-hearth or crucible steel quality" requires during two hours of operation 200 to 300 kw-hours.

The voltage and ampere curves are almost straight lines, so

that the furnace does not show any sudden load variations which would seriously react on the supply network.

The furnace capacity is about 1.5 tons. With star connection the voltage is 400 to 420, and the current 380 to 400 amp per phase. Since the power per phase is 200 to 230 kw-hours, the power factor is between 0.75 and 0.8.

An estimate of cost, which relates, of course, to German conditions, and a brief comparison of different electrical furnaces is also given. "The following furnaces only need to be considered in practice: the electrode furnaces of Héroult, Girod, and Stassano and the induction furnaces of Roechling-Rodenhauser and Kjellin [Colby]. There is no such thing like a universal furnace. All that can be said is that one or the other furnace has special advantages or disadvantages for special purposes."

Notes on Electrochemistry and Metallurgy in Great Britain.

(From our Special Correspondent.)

The Study of Breakages.

September has been, as always, a quiet month so far as scientific meetings are concerned. The British Association held its meetings in Dublin during the first week of the month, and the Iron and Steel Institute met at Middlesbrough during the last week. Other institutions are arranging their winter programs, which bid fair to be very heavy.

Of the British Association papers of special interest for these columns, mention must first be made of Mr. WALTER ROSENHAIN's paper on "The Study of Breakages." Mr. Rosenhain spoke as an apostle of investigation in regard to all breakage. Serious inquiry is seemingly reserved for those cases in which failure of materials has led to loss of life, in "the far greater number of cases, where the part in question is either of minor importance, or where the result is merely a temporary inconvenience which is rapidly forgotten, the question of the cause of the breakage is not, as a rule, examined with any great degree of care. Those immediately concerned no doubt form some idea of the cause, and endeavor to avoid its recurrence; but since the time and means at their disposal for such purposes are necessarily limited, while very frequently they do not possess that specialized knowledge which is required in such investigations, their conclusions are liable to be faulty, and such conclusions have in some cases become stereotyped into widely accepted but entirely mistaken views on the behavior of materials.

"Larger and more serious cases of failure or breakage often remain unstudied because the maker or manufacturer of the broken article sometimes prefers to accept the responsibility for the breakage, and to replace the broken object, provided that the matter is not investigated by experts. This attitude is apparently based on the view that, apart from the slight risk of publicity, expert investigation may lead to the establishment of more stringent tests or specifications. Actual experience of such investigations, however, shows that the recognition of the true cause of a failure is always of ultimate, and frequently of immediate service to the manufacturer of engineering materials."

Therefore Mr. Rosenhain proceeded to plead for a thorough investigation of cases of failure or breakage, pointing out that a frequent, and, indeed, nearly always an advisable, method of studying failures is to compare the broken article with a similar one which has given good service—this not only gives the investigator the means of applying the test of actual service to his conclusions, but incidentally it also throws valuable light on the relative importance of the various factors that are insisted upon by various specifications—and the effect upon the specifications is not by any means always in the direction of increased stringency.

It is not rare to find that material which from the point of view of the usual specifications would be regarded as superior

has failed, while material lying nearer to or even beyond the limits set by the specification has given good service. Of course, it is not suggested that any conclusions as to the correctness of the specifications should be drawn from isolated or even from a small number of instances of this kind, but the accumulation of such data, only derivable from a systematic study of breakages, would undoubtedly lead to a sounder appreciation of the relative importance of the various clauses of our specifications.

According to the stage at which the defect which has ultimately resulted in breakage has arisen, the causes of failure may be classed into three large groups:

Group 1.—Defects arising from the manufacture of the material of construction.

Group 2.—Defects arising from incorrect treatment of the material during the process of construction.

Group 3.—Defects arising during the life of the structure or machine.

The first of these groups is necessarily a very wide one, but if for the moment we confine our attention to the most widely used of our engineering materials—steel—a few of the more typical cases may be mentioned. Thus the material may be defective on account of the presence in it of undue quantities of impurities. Opinions differ widely as to what is to be regarded as "undue" in this respect, while the distribution of the impurities through the mass of metal is also of importance. The whole question of "segregation" and its relation to the soundness of steel arises in this connection, and is one of those which the systematic study of failures will gradually elucidate. It is obvious, however, that the investigator can arrive at a good idea of the nature of the material in this respect by means of chemical analyses of samples taken from different parts of the broken object.

The quality of the material as supplied by the maker is, however, obviously dependent upon other factors besides the simple question of correct chemical composition. Subsequent to its first manufacture into ingots the metal may have undergone deleterious treatment before passing on to the user. Thus the material—again in the case of steel—may have been overheated or even burned. The latter defect will be relatively easily recognized—the mechanical tests of the material will give bad results and microsections will at once reveal the cause, although in the case of metal which may have been heated by the user as well as by the original maker it will not always be possible to decide at which stage the damage was done.

Overheated steel is also readily recognized in the same way, but while the damage done by actual "burning" persists through all subsequent mechanical and thermal operations, the damage due to mere overheating can, it is believed, be undone by subsequent treatment. If this has actually occurred, it may happen that a piece here and there has escaped the refining operation and a weak piece comes through into the finished machine or structure. Such weak "patches" may be confined to quite small areas, so that careful investigation of the immediate vicinity of a fracture is essential to guard against overlooking such a point.

In many cases the manufacturer of the steel (or other metal) supplies it to the user in a partially finished form, such as forgings ready for machining. In that case the conduct of the forging and annealing operations may become a source of weakness; insufficient working by press or hammer, finishing at too high or at an excessively low temperature, and possibly imperfectly welded places where scale has been worked into the metal, may all give rise to subsequent failure. Again, unequal heating or cooling of large pieces of metal, and insufficient or unduly prolonged annealing, may also be mentioned. Such cases can generally be recognized by means of the microscope, great diversity of structure between different parts of the same forging being a very characteristic indication of some of the defects just named.

Such processes as punching or shearing, if at all carelessly

performed, or used in an improper manner as substitutes for more satisfactory but more expensive processes, may give rise to more or less unsuspected weaknesses. Thus, for example, the great ductility of mild steel naturally suggests that a considerable amount of cold working can be done without impairing its strength materially; but actual results have shown that cold working, particularly if applied at all locally, may be an exceedingly dangerous proceeding. It appears to be possible to entirely exhaust or destroy the ductility of a small portion of the metal if cold work is applied to it without proper precautions, and the local brittleness thus induced may result in the failure of the entire piece. Thus the hardened and brittle region which is produced when a plate is sheared in a bad shearing machine will cause the entire plate to crack across quite readily, and many other similar examples might be cited.

From the point of view of the investigation of breakages, the occurrence of undesirable cold working can generally be subsequently detected by the presence in the metal of regions of severe deformation. These are readily detected by the aid of the microscope, while mechanical tests reveal the local brittleness of the material at such points.

Turning to Group 3, we find a certain number of cases in which the most careful investigation can find no sign either of inherent defects in the material or of any injurious treatment during manufacture or construction; in these cases the metal has generally been subjected to undue stresses while actually in use, and has thus failed in the ordinary course of events. Actual faulty design—i.e., design imposing known, but unduly severe, stresses on sound material—is probably one of the rarest of such causes; but there are a number of others which come properly under this head, and these certainly occur at times.

Thus small errors in erection may at times throw undue stresses on certain parts—i.e., the design, either through inefficient construction or on account of its inherent difficulty, may not be correctly carried out. Probably more frequent, and therefore more serious are the operations of forces which do not readily lend themselves to calculation; as examples of the class of cases referred to, we may take the effects of thermal expansion and contraction arising in the case of steam boilers, and to a lesser extent in all heat engines. If by this or any other cause bearings are thrown out of line to a very slight extent, the alternating stresses that may be set up are often sufficient to account for the breakage of one of the parts concerned.

In investigating these cases one very useful line of evidence is obtainable from a study of the fracture itself; the details of the fractures of steel under various types of loading, as by direct tension, shock, alternate bending, etc., show characteristic differences, and a close examination of the fracture—if it is available in a sufficiently well preserved condition—will often enable the investigator to decide in what manner the breakage occurred. Beyond this he has, as a rule, only negative evidence to go upon; but if his study of the material of the broken part leads to the conclusion that the material was sound, then at least the manufacturer of the material is relieved from blame in the matter.

The paper concludes with four typical examples of failures with details of their investigation. The first was of the inner tube of a large gun which developed internal cracks and ultimately fissured completely after an abnormally short life. Tensile tests, alternating stress tests, and impact tests were made, as also detailed micrographic examinations, and the following summarized general conclusions deduced:

"The microscopic evidence, when correlated with the results of the mechanical tests, leads to the conclusion that as regards general composition, heat treatment, and mechanical treatment, the steel of the fractured gun-tube is normal, but that its strength is perceptibly impaired by the presence in its mass of a very large number of slag enclosures. The presence of these foreign bodies particularly reduces the power of the steel to

resist cracking transversely to the direction of forging, and the presence of longitudinal cracks in the tube is in accordance with this view."

The second case was that of the flanged plate of a thermal storage drum, which is now notorious in the annals of the English boiler explosions. This failure was due to severe strains set up by unduly hard cold working at the boiler maker's.

The third case was that of a locomotive crank pin which broke off in service with an apparently clean fairly smooth fracture. Mechanical tests, microscopic examinations and chemical analyses were made, with the result that it was proved that material which was originally of a satisfactory character had been spoiled by too severe a hardening process, and failed by a spreading of the hardening cracks which had thus been formed.

The fourth example described was that of a large shaft, intended to run at a high speed and to transmit a large amount of power; this shaft ran satisfactorily for some time, but ultimately fractured through a portion 12 in. in diameter. The fracture itself was peculiar in showing an outer ring, a little over an inch wide, which appeared rusty when the whole broke; this outer portion of the fracture was very smooth and fine-grained, but the central portions of the shaft had broken with a very rough, coarse-grained fracture. This was found to be a case in which steel of perfectly satisfactory composition has been put into use in a thoroughly unsatisfactory condition, and there can be little doubt from the evidence described above that the cause of this bad condition lay in the treatment received by the steel during the forging process.

The coarsely crystalline condition of the center of the shaft is one that has either persisted from the original coarse structure of the ingot, owing to insufficient work being put upon the piece during the forging, or it might—less probably—have been produced by considerable overheating, followed by a somewhat sudden cooling of the outside of the shaft. The latter conditions are unlikely to arise in ordinary forge operations, so that the former explanation remains as most probably correct. There can be no doubt at all that the coarse structure of the center of this shaft was present in the steel as supplied by the manufacturer, and cannot have been produced as the result of vibration or working stresses.

The description of these actual cases is certainly interesting and should serve to show the extent to which the application of modern methods renders possible the detection of causes of apparently mysterious failures. No doubt, cases may arise from time to time which baffle the resources of the investigator, but under favorable conditions considerable insight into such cases can be gained. These favorable conditions, which can often be realized by careful attention on the part of those under whose authority the fracture has occurred, may be summed up as follows:

1. Full information as to the exact circumstances of the failure, the service already undergone by the part in question, its origin, and any special circumstances concerning it.
2. Careful preservation of the fracture itself and of all portions of the fractured part, in order to avoid the covering up of important facts by the rapid accretion of dirt and rust which so frequently occurs.

* * *

The discussion of Mr. Rosenhain's paper was opened by Sir William White, who said that every engineer he thought would agree with the general statement that every failure should be thoroughly investigated, and would also agree that as a result highly valuable improvements in practice might be effected. At the same time, every engineer was better pleased when the failure was somebody else's, and still more pleased when that somebody would allow the publication of full details of the investigation. Here, however, the existence of the National Physical Laboratory removed many difficulties to such publications, as they might be safely relied on to treat the matter confidentially, and prevent names involved from becom-

ing public property. Coming to Mr. Rosenhain's suggestion that a thorough investigation might fix the separate responsibility for a fracture of the maker and the user, he would say that the user should be protected by a specification, providing that the metal furnished should receive only the usual treatment. That indeed was what these specifications were for. Thirty-five years ago, when they had begun to use mild steel for ship-building, it was his duty to draw up regulations governing both the manufacture of the metal and its subsequent treatment in the Government dockyards. Little was known at the time, and in the early days some very unpleasant discoveries were made; but in three or four years only things settled down to a practice, which, though subsequently improved on, had not been materially altered since. He was himself certain that no user or manufacturer would desire to keep secret knowledge which would lead to improved methods; provided only that in furnishing such data he should be put to no commercial disadvantage. The advancement of science was, no doubt, an admirable object, but business considerations were imperative.

The only other speech of importance was that of Captain H. Riall Sankey, who congratulated Mr. Rosenhain on the production of so valuable a paper. In this, however, the author had, of course, not dealt with every dangerous method of treating steel, among which the speaker considered continued forging at a low heat of an overheated forging particularly dangerous. If steel were heated above a temperature of 1200 deg. Cent. it took a coarsely crystalline structure, which gave a lower tensile test than properly treated steel. If such an overheated steel were afterward forged at too low a heat, this coarse crystalline structure was broken up, but the metal was rendered very brittle, as had been shown by Dr. Stanton's impact tests, and by the speaker's own bending machine. He thought that many of the so-called mysterious fractures originated thus—viz., by a forging being overheated and finally finished off at too low a heat. If such overheating did occur, the forging before being put into use should be annealed at 900 deg. Cent. and quenched, a procedure which, as Mr. Stead had shown, broke up the coarse crystals and produced a reliable metal.

In reply to the discussion Mr. Rosenhain said that the difficulty with respect to Sir William White's suggestion, that specifications should call for the ordinary treatment of steel, was to fix what this ordinary treatment should be. Not long ago the hammer dressing of plates constituted ordinary treatment. If a bulged plate came in, the bulge was taken out by cold hammering, which, it was considered, could not damage a material showing a 20 per cent elongation on 8 in. It was now recognized, however, that such hammering was most injurious. In short, the margin between the treatment which was perfectly safe and one which was dangerous was very narrow. He did not, of course, pretend to deal in his paper with all possible causes of failure; but referring to Captain Sankey's remarks on the danger of forging overheated metal at too low a temperature, he thought that the real remedy was "not to overheat the metal." The question as to whether steel heated beyond 1200 deg. Cent. could have its structure restored by annealing was a very open one. Personally, he was inclined to agree with Mr. Stead that the remedy was effective, but there were many who maintained that a steel once rendered brittle by overheating could not be restored by annealing. In any case there was a danger that some patch might escape being cooled sufficiently rapidly in the final quenching; and in examining fracture it was very necessary to look for evidences of this, of which he had come across several instances.

Electro-Analysis.

Also, at the British Association, Dr. HENRY J. S. SAND gave a demonstration of a process of electro-analysis, in which the principle of a very vigorous stirring of the electrolyte has been combined with that of keeping the potential of the cathode under control by means of an auxiliary electrode. It has thus

been possible very largely to extend the scope of electro-analytical methods. The following metals have hitherto been studied. First the metals of the silver and copper groups and zinc, i.e., silver, mercury, copper, bismuth, lead, cadmium, and zinc. These metals have all been deposited singly, separated from each other and also separated when all present in the same solution. In the last-named case the quantity of each metal taken varied between 0.10 and 0.15 gramme, and the time for the deposition of each between about 10 and 15 minutes. Secondly, new methods have been elaborated for the determination and separation from each other of antimony and tin. A considerable number of determinations have been carried out in which the metals taken in varying ratios weighed together approximately one gramme. The time for the deposition of the antimony was usually about 20 minutes, that for the tin about 80 minutes. Lastly, the possibility has been examined of securing a purely electro-analytical method for the analysis of an alloy consisting of copper, antimony, lead, and tin, and all the separations required for such an analysis have at the present time been carried out.

Dr. F. MOLLWO PERKIN and Mr. W. HUGHES also contributed a paper on this subject and showed two forms of apparatus for the same purpose as that of Dr. Sand. In the one case a rotating cathode in the form of an elongated thimble is used, a platinum gauze cylinder acting as anode; and in the other case a spiral anode of platinum is employed, and a gauze cylinder serves as cathode. It was also shown how this apparatus could be used for depositions by means of the graded potentials when an auxiliary electrode is employed to maintain a constant potential.

Parabolic Reflectors.

Mr. SHERARD COWPER-COLES described his method for the production of true metallic surfaces for parabolic reflectors, in which the mirrors are deposited electrolytically on a carefully ground glass mold. The preparation of this mold is a long and costly operation, but when once prepared the reflecting surface can be reproduced in metal any number of times at a fraction of the cost, thus enabling mirrors of a true parabolic curve to be manufactured at a very cheap rate. The mold is coated with a thin film of silver on the convex side by a chemical process, and mounted in a metallic ring, which makes contact with the silver film, and is then suspended with the convex side downward on a spindle, placed above an electrolytic cell for depositing copper. The spindle is rotated at 5 to 10 revolutions per minute, while the copper is being deposited on the silver coating until a sufficient thickness has been obtained to give the necessary rigidity. The glass mold and copper deposit is then placed in warm water and gradually heated until the expansion of the copper causes it to leave the glass mold. The mirror thus produced has a surface as highly polished as the glass, and of exactly the same curvature. A silver-faced mirror thus produced would tarnish and be scratched too readily for practical purposes, so it has to be faced with some harder untarnishable metal or alloy. The metals usually employed for this purpose are platinum, palladium, or an alloy of silver and cadmium, which are deposited in a bright form.

The Ionic Theory.

Professor ARMSTRONG is still among the unconverted, and therefore in opening a discussion on the ionic theory at the British Association, it is not surprising to still find him a hostile critic. He started by saying that the assumption of independent ions in solution had not been experimentally proved, and he did not believe that hydrochloric acid, for example, was dissociated in aqueous solution into H cations and Cl anions, but that in contra-distinction to dissociation there is an association between the water molecules and hydrochloric acid in solution



and he considers that when an e.m.f. acts, it is sufficient to break down this unstable molecular complex, and then the chlorine will be carried to the one pole and hydrogen to the other. He likewise affirmed that there was no proof and no probability that water itself was to a certain extent dissociated into H and OH ions.

In the discussion which followed, Sir Oliver Lodge remarked that physicists had no objection to imagining hydrations of ions. They also had no particular objection to the formula for hydrochloric acid in solution which had been put upon the board. Armstrong was getting nearer to the physical chemist than he had ever done before. Sir William Ramsay remarked that as all mention of electrons had been omitted it was hardly possible to discuss the question because chemists looked upon electrons as constituents of ions. Prof. Armstrong considered that this only added to the confusion.

SYNOPSIS OF CURRENT LITERATURE.

Electrochemistry.

Fundamental Units.—The National Physical Laboratory (Great Britain) has presented through the British Association at its Dublin meeting a complete set of "Specifications for the Practical Realization of the International Ohm and the International Ampere, and Instruction for the Preparation of the Weston Standard Cell." These specifications will be brought up at the London meeting of the international committee on electrical units for adoption. They are published in detail in the Sept. 18 number of *The Electrician* (London), from which are taken verbatim the directions concerning the production of the international ohm, this having never been published before.

The international ohm shall be the resistance offered to an unvarying electric current by a column of mercury at the temperature of melting ice, 14.4521 grams in mass, of a constant cross-sectional area, and 106.300 cm in length, arranged in accordance with the following specifications. The column of mercury shall be of constant cross-section or nearly so, and shall be contained in a glass tube of suitable composition, which has been carefully annealed. The tube shall be straight to the eye, and the maximum variation in its area of cross-section shall not exceed 2 parts in 100. The tube is to be carefully calibrated, and the correction for its conicality carefully determined. In determining the weight of mercury contained in the tube when filled at the temperature of melting ice, the column of mercury is to be bounded by planes at the terminal cross-section of the tube. The tube should not be unduly heated, and it should be filled with mercury by the exhaustion of the air. The axial length of the tube should be measured at 0° C., if possible, otherwise the coefficient of expansion of the glass determined and the axial length of the tube at 0° C. calculated from axial measurements made very near that temperature. To facilitate axial measurements of the tube, the ends of the tube should be ground very slightly convex. For electrical measurements the ends of the tube are to be connected to spherical bulbs of glass, the slightly convex ends of the tube forming, very nearly, portions of the internal spherical surfaces of the bulbs. Each bulb is to be provided with a current and a potential lead, the point of entry of the former and the end of the tube being at opposite ends of a diameter of the bulb. The potential lead shall be situated in a plane midway between the point of entry of the current lead and the end of the tube, and at right angles to the line connecting them. Contact with the mercury shall be made by means of platinum wires. The diameter of the bulb shall be from 30 to 33 times the diameter of the terminating section of the end of the tube to which it is to be connected.

If L is the axial length in centimeters of the mercury column contained in the tube at 0° C., W the weight of the mercury in the column in grams, and u the correction for conicality of the tube, the resistance of the column at 0° C. is

$$= \frac{L^2}{(106.300)^2} \cdot \frac{14.4521}{W} = 0.001278982 \frac{L^2}{W} \text{ international ohms.}$$

Where the spherical bulbs are fitted to the ends of the tube and the whole filled with mercury, if r is the mean radius of the tube and r_1 and r_2 the mean radii in centimeters of the terminal sections, the resistance at 0° C. between the potential leads is

$$0.001278982 \frac{L^3}{W} \left\{ u + 0.80r^2 \frac{(r_1 + r_2/r_1 r_2)}{L} \right\} \text{ international ohms.}$$

Correct to 1 per cent of the added resistance

$$0.001278982 \frac{L}{W} \left\{ 0.80r^2 (r_1 + r_2/r_1 r_2) \right\}$$

The factor 0.80 has been assumed tentatively; it will later be fixed at the Congress of Units.

The electrical measurements are to be carried out at 0° C., the tube and spherical vessels being surrounded by melting ice and about 15 centimeters below the surface of the ice. The connecting wires employed for the current and potential leads must be thin, the flow of heat through them to the mercury being insufficient to warm the mercury so as to produce an appreciable error. The insulation resistance between the mercury column and the ice surrounding the tube must be no less than 10,000,000 ohms. The current employed in comparing the mercury resistance with the other resistances shall be limited by the condition that the mercury shall not be warmed sufficiently to produce appreciable error. The mean of at least five tubes must be taken to determine the value of the mercury unit. The mean of at least three fillings shall be taken as the value of the resistance of a tube.

Cadmium Cell.—R. Jouast has made some researches on the "Influence of temperature on the e.m.f. of the cadmium cell." The original appeared in *Comptes Rendus*, only a translation of which appears in the *London Electrician* of Sept. 18. The formula, given by Jager and Lindeck, $E_t = E_{20} - 0.000038 (t - 20) - 0.00000065 (t - 20)^2$, is applicable down to 0° C. for cells whose negative electrode consists of an amalgam containing 12 or 13 per cent cadmium. Some cells containing a 14 per cent amalgam showed irregularities as great as several ten-thousandths of a volt in the neighborhood of zero. A series of experiments made in the Laboratory d'Electricite showed that with cells containing a 12.5 per cent amalgam the e.m.f. at 0° C. was about one ten-thousandth of a volt less than that indicated by the formula. The formula does not, however, apply to cells containing a 10 per cent amalgam. They agree closely with the value given by the formula at 10° C., but at zero differ between themselves and are higher than indicated by the formula by as much as one-thousandth of a volt. No explanation of this apparent difference and also of the slow attainment of a constant value of these 10 per cent cells is given, it only being recommended that they be not used below 10° C.

Chemical Engineering.

Producer Gas.—In a paper read before Section G of the British Association at Dublin by J. Emerson Dowson some interesting comparisons are made between suction and pressure gas, as he classifies the two kinds, depending on the method of introducing the air to the producer. The calorific power of pressure gas made with a jet of superheated steam is usually higher than that of suction gas. In the former the percentages of hydrogen and carbon monoxide are higher, while the percentage of nitrogen is lower. If the gas is to be used for heating purposes in small burners or in blowpipes it is better to use pressure gas than suction gas. Suction gas contains a smaller percentage of combustible than pressure gas, requires less air for combustion, but as the loss from fluid friction is greater an engine using suction gas develops less maximum power, this power loss becoming serious in engines above 200 hp. Fuel consumption in a pressure plant with independent boiler is higher than in a suction plant. The suction plant costs less and occupies less space, but the gas made is not so strong as with a pressure plant. For small plants anthracite or gas coke should

be used for fuel, the labor and plant necessary for removing the tar in small installations more than offsetting the cost of the cheaper bituminous coal. For large plants this latter fuel is always used.

Peat.—Before this same section was also read a paper on "The utilization of peat for making gas or charcoal with recovery of by-products," by H. Riall Sankey. This subject has received considerable importance in Ireland from the proposed bill asking permission to build a power station and to supply power at Robertson, 25 miles from Dublin, the fuel to be used being peat. By using a mechanical excavating bucket it is estimated that the peat can be cut and passed through a Dornberg press for 75 cents a ton. The Ekenberg process of drying peat may find application here. When peat containing over 90 per cent water is exposed to a temperature of over 150° C. the slimy hydro-cellulose is decomposed and the peat is partly carbonized. In this condition the peat can be squeezed practically dry. No by-products are lost. Dr. Ekenberg gives as the cost of the operation 75 cents per ton of dry peat produced. Gas producers suitable for the production of gas from lignite, of which there are a number on the market, are suitable for peat burning. Their capacity is somewhat less than when running on lignite. An average analysis of dry gas is given as CO, 12 per cent; CO₂, 18; CH₄, 2.8; H, 24; N, 43.2. The only by-product so far recovered in a gas plant using peat as fuel is sulphate of ammonia, the recovery being reported as worth \$1 per ton of peat burned, the original cost of the peat being only 75 cents. This output is rather a variable factor, depending on the proportion of nitrogen in the peat. An experimentally proven power output of 1000 boiler horse-power hours per ton of peat burned in the producer would fix the cost at about 0.1 cent per horse-power hour, not including profit from recovery of by-products. (The subject of utilization of peat was fully discussed in our Vol. V, pp. 392 and 405).

Of considerable interest are some remarks made in the discussion by Mr. Crossley, of the well-known firm of gas engine makers, who, according to the *London Electrician* of Sept. 11, thought that at last there was a prospect of some success being achieved. He supported Capt. Sankey's statement that peat was economical, even if it contained as much as 60 per cent of moisture; his own company had proved this by experiment. With regard to the application of peat fuel to the production of electrical energy, he maintained that, owing to the value of by-products, the fuel costs would be reduced to zero. He gave figures relating to a plant for the carbonization of 10 tons of dry peat per hour; the capital cost was put at \$250,000, and it was estimated that each ton of peat would produce 140 tons, or even 170 tons, of ammonium sulphate. Putting the amount of nitrogen in dry peat as 2.2 per cent, and allowing a suitable amount for depreciation of plant, etc., the profit worked out at \$120,000 per annum. On this basis the cost of production per ton of sulphate was about \$27.50, while the selling price was \$57.50. These figures make no allowance for the sale of gas.

Iron and Steel.

Corrosion.—The corrosion of iron is still the center of numerous investigations, W. A. Tilden presenting a new series of experiments in the *Journal of the Chemical Society* for July. Soft Swedish iron was used in all the experiments in the form of rods, 3/4 in. in diameter, turned bright and polished with emery. The Moody experiments were repeated with three rods, one-half of one bright, the other half file-roughed; the second was heated in hydrogen to reduce the scale and then red hot in a vacuum; the third was exposed to a 1 per cent solution of chromic acid; all were placed in the same piece of tubing. Air which had bubbled through and stood in contact with KOH solution was passed over the iron for five days, and then water was distilled onto it. Samples 1 and 2 rusted inside 20 minutes, 3 not at all. After six months' standing 3 showed only a small patch of rust, and that was noted a short time after the experiment was started. Next the iron was subjected to a current of

most carefully purified oxygen for three days, and then water was distilled onto it. Rusting took place in 10 minutes. On repeating the experiments with greater precautions for excluding CO_2 , the iron rusted in 20 minutes. No action was noted with water on iron treated with chromic acid, provided the water contained no other substances. Walker's experiments on the solution of iron in water were repeated and his conclusions confirmed. Iron goes into solution as $\text{Fe}(\text{OH})_2$; in air this becomes FeCO_3 . Analysis of iron rust 250 years old showed 9.2 per cent ferrous iron; total iron, 62.65 per cent. The following facts were considered to have been established: Metallic iron water and oxygen are alone sufficient for the production of rust; CO_2 is not necessary, but its presence assists in the production of rust; iron is attacked by pure water in the absence of O and CO_2 , the product being $\text{Fe}(\text{OH})_2$; iron rust always contains FeO . The process of rusting is due to electrolytic action, the products being $\text{Fe}(\text{OH})_2$ or FeCO_3 and may be explained by the presence in the iron of various compounds which form surfaces of different potential in the electrolyte of water or aqueous carbonic acid.

Along a directly opposite line from the preceding is a paper on "passivity in acid solution," by J. Alvares, appearing in *Zeitschrift für Elektrochemie*, Sept. 11. This may be mentioned here, although not relating to iron. A nickel anode was dipped into a 5-n sulphuric acid solution, the cathode of the cell being formed of a heavy copper spiral dipping into a copper sulphate solution in a clay cell. The voltage across the terminals of the cell for a given applied current was:

Current.	Voltage.
0.05	0.15
0.055	0.17
0.060	0.185
0.065	0.20
0.070	0.22
0.080	0.24
0.085	1.75

Thus it appears that a certain current density is necessary to make the nickel anode passive; above 1.5 volts tension across the terminals of the cell oxygen was evolved from the anode. Below that tension solution took place according to Faraday's law, while above practically no solution took place. The addition of a halogen salt lowered the required current density, though the anomalous result was arrived at that increasing additions of halogen salt caused a rise in the necessary current density for making the anode passive. The cause of the phenomenon of passivity is believed to be due to the formation of an insoluble hydroxide or basic sulphate precipitate on the surface of the nickel. The author proposes this explanation of the formation of this coat: It must be assumed that the transport of negative electricity to the anode is due to the precipitation of negative anions like oxygen. The charged oxygen combines with the metal of the anode and the oxide formed dissolves in the solution.

If the delivery of oxygen to the anode is more rapid than the oxide formed can dissolve, then the electrode becomes covered with the insoluble coat and becomes passive. It is only when the depolarization of the anions by metal takes place as fast or faster than the current delivers them that the electrode dissolves according to Faraday's law.

Blast Furnace.—The lighting of a blast furnace has always been more or less of a problem to the furnace men, and Mr. C. S. Proudfoot will no doubt incur the thanks of a large number of them for the convenient little electric apparatus that he has devised for this purpose. It is described in *Iron Age*, Sept. 17. A short section of electric conduit is fitted with an iron point. One-half of it is cut away just behind the point, and in the trough thus formed is placed two pieces of electric light carbon insulated from each other. Their ends are brought within $\frac{1}{4}$ in. of each other, and this gap is bridged with a short piece of 3 amp fuse wire. The carbons are connected to leads, which in turn through suitable resistance are connected with

the arc circuit of the plant. A mass of excelsior, saturated with alcohol, is tied over the gap between the carbons. In use the igniter so prepared is pushed in through a tuyere, connection made with the lighting circuit, the fuse blows, springs an arc between the ends of the carbon, and so lights the excelsior. In practice four are used at one time.

Some light is at last thrown on the cause of a number of mysterious blast furnace explosions by W. van Vloten in an article in the July 15 number of *Stahl u. Eisen*. The cause of these explosions are believed to be generally due to the sudden and intimate mixture of a mass of fine ore and fine coke at a red heat. In most cases the explosions follow by several seconds a slip in the furnace. It is impossible to conceive of their being produced by a mixture of air and gas, because it is not possible to introduce air at the point where they have usually shown their greatest destructive action. In proof of this theory the author took a large diameter tube, inside of which was placed two smaller tubes filled with ore, the space surrounding these tubes being filled with fine coke. On heating the free end red hot and suddenly inverting the whole so that the fine coke and the ore were intimately mixed at a red heat, an explosion took place, which recorded a pressure of 4 At. on a pressure gauge attached to the large tube. No explanations are offered as to why explosions are more frequent when the furnace is charged too frequently in the center.

Foundry Cupola.—In a paper on "foundry cupola construction," read before the New England Foundrymen's Association at Boston, Sept. 9 (reprinted in *Iron Age*, Sept. 24), Mr. T. D. West divides the demands made on the cupola in special and general practice into 14 classes, each requiring a special cupola. For continuous running the cupola should have the main tuyeres 3 to 4 ft. above the bottom plate and the slag hole 12 to 18 in. below the lower row of tuyeres; the height should be 16 to 20 ft., the inside diameter 60 in. and the walls straight. For intermittent running all parts of the cupola should be so designed as to permit of being closed air tight. For melting fine and dirty scrap, steel scrap, tin scrap and sheet iron mixed with pig iron the cupola should be provided with two rows of tuyeres, the lower row 24 to 36 in. above the bottom plate and 36 to 50 in. in diameter; if above 60 in. in diameter this cupola should be provided with center blast. It should not be over 16 ft. high. For the rapid melting of large heats the tuyeres should be high, a slag hole 8 to 12 in. below the tuyere level should be provided, and a pressure of 8 to 12 oz. for the blast passing in through large tuyeres is essential. The cupola for this purpose should be boshed if over 50 in. in diameter. Where rapidity of melting is the only desideratum the tuyere level should be low, no slag hole is necessary, and the walls should be boshed for cupolas over 40 in. in diameter; if over 60 in. a center blast is necessary. The question of fuel economy is more concerned with the handling of the cupola than with its general design. The highest economy is attained by working to the fullest capacity of the cupola, to attain which the center blast should be used for furnaces over 60 in. in diameter, with the lowest row of tuyeres 18 to 24 in. above the bottom plate. For continuous tapping a larger tuyere area must be supplied than for intermittent tapping. When coal is used for fuel smaller and lower tuyeres are required than for coke. A second row of tuyeres means a new smelting zone, with consequent wear and tear on the lining. A tap hole requires the use of limestone as flux. A center blast allows of the use of lower blast pressures.

One of the greatest disadvantages of the foundry cupola is the fact that as ordinarily driven it cannot be used for melting low carbon irons. As the engineer is often looking for a cheap material intermediate between cast iron and low carbon cast steel, he is forced to use a substitute. Such a product may be made in the Siemens-Martin or the reverberatory furnace, but the cost is excessive. Before the Köln-Aachner Section of German Iron Founders, K. Schiel read a paper on the use of oil for firing cupolas. The paper is printed in detail in *Stahl und Eisen*, Aug. 19. The cost of oil firing is but slightly higher

the tank is used at ordinary temperatures. The composition of the bath may be held constant by using insoluble anodes, which facilitate the oxidation of about as much chromic oxide to chromium trioxide, as chromium trioxide is reduced at the cathode. Anodes of fused ferroferric oxide, Fe_2O_3 , are recommended.

Silver Reflector.—Incandescent electric lamp globes are often silver plated to a certain extent to produce a reflector for the light and it has been the practice to coat the silver film with varnish. This has the disadvantage that the heat of the lamp causes the varnish to curl up, pulling the silver from the glass. J. A. Yunck (900,340, Oct. 6, 1908) coats the silver film with the protective layer of copper by electrodeposition. For this purpose he uses a special copper anode so shaped as to conform to the outside surface of the lamp bulb in order to produce a uniform deposit.

Seamless Plated Wire.—Ingots suitable for reduction into seamless gold or silver plated wire for jewelers' use are made by electroplating a layer of gold and silver on a core of common metal according to a process of F. Cutter (899,827, Sept. 29, 1908). Such plated rods are then subjected to heating and pressure by means of shot. For this purpose the coated rod is placed in an ordinary rattling barrel containing shot and the drum is rotated. By mixing a liquid soap with the shot a more polished surface is secured. If a thin plating of metal is all that is desired, the ingot is then ready for reduction to seamless wire. If a heavier plating is demanded, the above process of plating and beating is repeated.

Plating the Inside of a Tube.—G. A. Lutz (899,226, Sept. 22, 1908) plates the inside and outside of tubes by immersing them in a tank containing anodes around the tubes and also anode rods inside within the tubes. Instead of such a solid metallic anode rod a perforated insulating tube may be used containing pieces of the anode metal, which are, of course, connected to the positive pole of the electric circuit.

Plating Small Articles in Mass.—J. T. Daniels (901,280, Oct. 13, 1908) uses a tank with a rotatable container for the articles to be plated. The anodes are placed in the tank outside of the container. The container is placed in an inclined position (neither horizontal nor vertical), and is of truncated cone shape. In the center of its rather extended bottom the cathode is provided. The walls of the container are, of course, perforated. When the container is rotated and the circuit is closed, the small articles are pressed not only by gravity, but by centrifugal force against the cathode and against each other to intensify the electrical contact. At the same time the electrolyte is thoroughly agitated within the container so as to bring always fresh metal solution to the surfaces to be plated.

Plating Metal Sheets.—H. L. Hollis (900,169, Oct. 6, 1908) patents mechanical details of an apparatus for electroplating metal sheets. A number of vertical rotatable rollers are so disposed as to convey the sheets through the plating bath. The rollers are so spaced that one set of rollers engages a sheet before the preceding set releases it, in order to secure a continuous movement of the sheet through the bath.

Lead Peroxide Electrodes.—An indestructible anode is an important requirement for many electrolytic processes. Platinum is excellent for many purposes, though very expensive. Artificial graphite has been found to be an ideal material for many processes like electrolysis of chlorides, but it is not recommended for the electrolysis of sulphates. Lead peroxide plates have also been used in various cases. P. Ferchland and J. Nussbaum (900,502, Oct. 6, 1908) make such lead peroxide electrodes by using metallic rods or plates (which form the core of the final electrode) as anodes in a strong solution of nitrate of lead, containing, say, 25 per cent of salt. Colloidal substances, such as gum arabic, etc., may be added in order to make the deposit more smooth and glossy. The anodes are rotated. Cathodes of copper or other metal are used. The anode current density is 6 amp per square decimeter.

Purifying Liquids.—There is no lack of patents for purify-

ing liquids by electrolysis. Most of them employ electrodes forming a hydroxide which combines with and coagulates the organic matter in the water. This is also the case in the patent of J. T. Harris (900,926, Oct. 13, 1908). He uses iron anodes for this purpose, but he also employs a magnetic field acting upon the iron anodes and the liquid in contact with them. He further agitates the water by injecting upward through it bubbles of filtered air, which may be partially ozonized. He ascribes the formation of the voluminous, colloidal hydroxide to "the combined action of the electric current, magnetic field and injected air."

Diaphragm Cell.—A. S. Gray (884,015, April 7, 1908) builds a diaphragm cell with horizontal anodes and cathodes separated by a canvas diaphragm. The cathodes are at the top. The cell is placed in an inclined position to permit the hydrogen gas evolved at the cathode to escape. To facilitate the further escape of the gas, the cathode chamber is provided with numerous vent openings, which connect with tubes leading to the outside.

Solvent.—E. C. Broadwell (884,705, April 14, 1908) patents a solution which is not only claimed to be a good solvent for metals, but also a suitable electrolyte for later depositing the metals without evolution by hydrogen. The solvent consists of the sulfonic acids of the carbocyclic hydrocarbons, or of the carbocyclic oxy-compounds, such as the phenols, aldehydes and carboxylic acids.

Batteries.

Storage Batteries.—To give greater mechanical strength to the active masses of storage batteries, M. C. Thiellet and M. J. Denard (900,898, Oct. 13, 1908) mix the lead oxides used for preparation with "gelatine gelatinized in aqueous bichromate of potash, and asbestos fiber emulsified in sulphuric acid and silicate of soda." Detailed instructions on the procedure are given.

W. Morrison (900,571, Oct. 6, 1908) uses a zinc battery with horizontal electrodes, separated from each other by an insulating diaphragm resting on the lower electrode and supporting the upper one. The lower electrode consists of a number of superimposed screens intended to receive the zinc. Since all the zinc is intended to be at the bottom of the cell and since the cell itself has metal walls, it is necessary to line the inside with an insulating band. This insulating lining rests on the edges of the lower zinc electrode.

H. C. Hubbell (897,833, Sept. 1, 1908) makes small alkaline batteries of the general Edison-Jungner type for use with transportable lamps. The active material of the positive plate is formed of 60 per cent nickel hydrate $\text{Ni}(\text{OH})_2$ and 40 per cent silver oxide Ag_2O , which are reduced to an impalpable powder, mixed and pressed into the form of a tablet. The negative plate is a similar pressed tablet of mixed cadmium oxide and an impalpable powder of metallic nickel. The electrolyte is sodium or potassium hydroxide.

Primary Batteries.—W. A. F. Bleack (899,823, Sept. 29, 1908) patents the construction of a double-fluid primary cell with a zinc electrode in an "exciting" solution of one part of sodium hydroxide in two parts of water. The other electrode is made of carbon and is placed in the depolarizer. The exciter is separated from the depolarizer by a porous partition. The depolarizer is made by dissolving 5 oz. of chromic acid in 10 oz. of a 3 per cent solution of hydrogen peroxide in water and by adding 5 oz. of hydrochloric acid.

I. Kitsee (901,012, Oct. 13, 1908) tries to avoid the depolarization of the carbon element of a primary battery by the catalytic action of platinum black. He states that it is necessary to supply oxygen to keep up the catalytic action. For this purpose he makes use, for instance, of a carbon disk covered with platinum black and rotates it. Parts of the surface are thereby brought out of the electrolyte and in contact with air, which provides new oxygen.

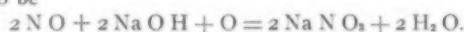
Mechanical Details.—A patent of J. Marx (897,472, Sept.

1, 1908) refers to details of construction of a jar for storage batteries. It has an inner shell of acid-resisting hard rubber and an outside protective casing of metal.

H. J. Brewer (900,476, Oct. 6, 1908) patents details of construction of a cover for primary batteries. The cover is provided with a radial slot for receiving the carbon electrode.

Electric Discharges Through Gases.

Fixation of Atmospheric Nitrogen.—By means of arc and spark discharges through atmospheric air it is possible to force part of the oxygen and nitrogen of the air into a chemical combination. But the further treatment of the resulting gas mixture still offers difficulties. C. N. Riiber (899,705, Sept. 29, 1908) endeavors to produce pure nitrites free from nitrates. For this purpose the gases from the electric apparatus are at once directed into absorption apparatus containing alkalies or alkaline earths, and before the oxidation of the nitric oxide NO to nitrogen dioxide NO₂ takes place. The gases may be advantageously cooled. The reaction which takes place is stated to be



Ozone.—J. R. Craig, Jr. (894,818, Aug. 4, 1908), patents the construction of electrodes for the production of ozone by silent high-tension discharges. His electrode unit consists essentially of a strip of micanite, on each side edge of which, near the top and near the bottom, are fastened little metal projections to the micanite. On each side a metal spring is stretched between the two projections. The two opposite metal springs are electrically connected to the two poles of the high-tension circuit. "The springs, when charging and discharging the dielectric medium, will vibrate synchronously with the interruptions or cycles of the high-tension current." Modifications of the construction and the methods of assembling a number of such electrode-units into a compound electrode are also described.

To prevent the destruction of the electrodes in an ozonizer, J. R. Quain (898,506, Sept. 15, 1908) proposes to use both of them in vacuo. Each electrode is contained in a vacuum tube and the vacuum tubes are placed in a parallel position, the air to be ozonized passing along the exterior of the tubes in the direction of their lengths.

RECENT METALLURGICAL PATENTS

Iron and Steel.

Blast Furnace.—To prevent any danger of clogging, sticking or hanging of the contents or burden of a blast furnace with the result of a slip, J. H. Meissner (900,291, Oct. 6) proposes to make the bosh independent of the hearth. A special structure is provided to support the bosh, and the latter can be made to rotate. By giving this section a slow, steady movement at desired intervals, the feed of the ore past this section into the hearth below is insured. Naturally this means a somewhat complicated construction and it is necessary to keep the joints between the movable and the adjoining stationary sections cool, so as to prevent an outflow of fluid from the interior of the furnace. For this purpose artificial cooling of the joints by means of water boxes is employed and air pressure is applied to the exterior of the joints. The walls of the bosh are kept cool by moist layers of sand, held in position by means of screens and continually moistened by a flow of water from perforated pipes. This arrangement is stated to be much cheaper than the bronze plating now employed. It is said that in operation it is ordinarily necessary to give the bosh a slow back and forward movement only at intervals.

Basic Open-hearth Steel.—Heretofore it has been considered impracticable to melt a charge of pure wrought iron in an open-hearth furnace without the addition of pig iron. A process of J. W. Maxwell (900,564, Oct. 6) is said to make this possible. It is said to yield steel of any carbon content de-

sired, from very soft to extremely hard, from iron and steel scrap with the use of pig iron. The process is as follows: Pig iron in small quantities, and preferably a neutral pig iron, that is, a pig iron low in silicon and phosphorus, together with limestone, lime or other suitable material containing calcium, are first charged into an ordinary open-hearth furnace. A quantity of charcoal, coal or coke is then quickly spread over the charge of pig iron and limestone, the quantity being such as to give the required or a greater percentage of carbon than is necessary to secure the required percentage of carbon in the finished steel. This carbonaceous material is then quickly covered by the scrap iron or steel to be used, so as to protect it from exposure to the free oxygen in the flame in the furnace, as the object in using a carbonaceous material in this way is not to secure heat for melting the charge, but solely to add carbon to the scrap iron or steel used. When thus treated, a charge of scrap iron or steel absorbs or takes up enough carbon during the melting period to not only lower the melting point enough so that they are readily melted at the ordinary temperature maintained in an open-hearth furnace, but also to produce steel of a very high carbon from very pure materials if so desired. After the charge has been melted down as described, the refining of the bath is then proceeded with in the ordinary manner, and after the required refining has been accomplished and the carbon reduced to the desired percentage, the bath is tapped out of the furnace, the usual final addition of ferro-manganese, ferro-silicon, aluminium, etc., being added either in the furnace or in the ladle.

Nickel, etc., from Matte.

Removal of Arsenic, Recovery of Silver, Nickel, Cobalt, etc.—Three recent patents of A. J. Wadhams and R. C. Stanley (900,452, 900,453, 900,454, all of Oct. 6, 1908, and all assigned to the International Nickel Company) refer to the complex problem of separating the copper, nickel, cobalt, silver and arsenic, contained together in speiss or other arsenical matte.

Removal of Arsenic forms the first part of the process. The speiss is roasted in a calcining furnace at a cherry-red heat until the arsenical fumes cease to come off. The calcined material is then ground with coal or charcoal and roasted in a reducing atmosphere, which reduces the arsenical compounds to arsenides. This is followed by an oxidizing roast which liberates arsenic fumes. The alternate reduction and oxidation are repeated until the fumes of arsenic cease to be liberated. Material which originally contained 35 per cent arsenic, 16 nickel, 25 cobalt and 10 iron, will contain at this stage about 4 per cent of arsenic. The further treatment may be carried on by either of the following two methods, A or B.

Treatment A: The material is ground to 80 mesh and treated with sulphuric acid of 35° B at boiling temperature, dissolving a large proportion of the silver and some of the copper, nickel and cobalt. By passing the solution over copper shot or copper sheets, the silver is separated by cementing and is then washed, dried and smelted. The remaining solution is neutralized with caustic soda and evaporated to 40° B., whereby the nickel and cobalt are precipitated as crystalline sulphates. The crystals are calcined and changed into oxides, which are dissolved in hydrochloric acid. The iron is precipitated with lime, leaving a solution of chlorides of copper, nickel and cobalt, and a small proportion of silver chloride. The residual silver is precipitated with hydrogen sulphide, and the nickel and cobalt are separated by known methods.

Treatment B, instead of A, is more elaborate and proceeds as follows: The material, resulting from the previous treatment, is mixed with 1 part of nitrate of soda and 2 parts of soda ash to each part of arsenic contained in the material, and the mixture is calcined at a cherry-red heat, until all the arsenic is converted into arsenate of soda. The material is withdrawn from the furnace and washed in a wash tank until the arsenate of soda is dissolved. The solution is concentrated by evaporation and the arsenate of soda crystals form a valuable by-

product. In this way the content of the arsenic in the undissolved material can be reduced to 0.5 per cent.

The residual material consists of oxides of copper, nickel, cobalt, iron, silicon, aluminium and calcium and of metallic silver. It is treated with concentrated hydrochloric acid in a revolving cylinder at a pressure of about 60 lb. to 80 lb. and a temperature of 135° Fahr. for six to eight hours. The hydrochloric acid dissolves the chlorides of the several metals except most of the silver. The undissolved silver and silver chloride are allowed to settle for subsequent removal and smelting. The solution is drawn off and by means of caustic lime the iron is precipitated as a hydrate and the last of arsenic is removed. The solution, freed from iron and still acid, is treated for the removal of copper and silver by passing sulphuretted hydrogen through it, which precipitates the copper and silver as sulphides, which are washed, collected and smelted. The remaining solution contains chlorides of nickel and cobalt, which are separated by known methods.

Zinc.

Low-Grade Sulphide Ores.—A patent of F. P. Dewey (900,088, Oct. 6, 1908) relates to the conversion of zinc oxide into sulphite of zinc and particularly to the treatment of the mixture of galena, pyrite and blende, carrying a small amount of silver, which is commonly spoken of as "low-grade sulphide ore." Various processes have been proposed, in which the ore is roasted and then treated with the sulphurous acid given off in roasting, in order to convert the zinc into sulphite, which is dissolved in water, and separated from the residue containing the lead, iron and silver. For such schemes it is important to bring the zinc of the roasted ore into solution in a minimum quantity of water, and this the present inventor tries to secure by the use of a very large amount of sulphurous acid applied in a particular manner. The fundamental fact is that the amount of oxide of zinc held in solution by sulphurous acid water depends upon the amount of sulphurous acid present in excess of the quantity required to convert the zinc oxide into sulphite; and that the ores under consideration do not yield sufficient sulphurous acid on being roasted to get such concentrated solutions. It is, therefore, necessary to have an excess of sulphurous acid, and this the inventor obtains by the subsequent manipulation of the solution of sulphite of zinc and the decomposition of the zinc sulphide itself, so that he uses his sulphurous acid over and over again, and thus has an abundant supply of sulphurous acid and a continuous process.

His concentrated solutions of sulphite of zinc in sulphurous acid water deposit crystals of zinc sulphite, on losing their excess of free sulphuric acid. This is accomplished by heating or by applying a vacuum, or by both means. The evolved sulphurous acid is passed into a new charge of roasted ore. The solution deprived of its excess of sulphurous acid gas will still contain some zinc, and, in order not to waste this, the liquid is cooled and then recharged with sulphurous acid and used in treating a fresh lot of ore so as to saturate it again with zinc. Further, it is a fact that in dissolving zinc oxide in sulphurous acid water, it is easier to keep the zinc dissolved in a small volume of water than it is to dissolve already formed zinc sulphite in the same amount of water. During the dissolving operation any separation of zinc sulphite is, therefore, avoided. This is secured by always having an excess of free sulphurous acid present in the solution. The roasted ore is added in small portions at a time to the sulphurous acid water and fresh sulphurous acid gas is supplied to the solution while the zinc is being dissolved. The zinc sulphite crystals finally obtained, when heated for a short time to 1000° C., are completely decomposed and yield a very pure zinc oxide, practically free from sulphur (less than 0.01 per cent).

Zinc Alloy.—According to W. J. Leddell (901,014, Oct. 13, 1908) an alloy containing 90 per cent zinc, 5 aluminium and 5 copper, has a relatively low factor of shrinkage, and a relatively high resistance to distortion from impact or pressure. It

has a dense, homogeneous structure, substantially free from segregated masses of crystallized zinc. It is said to be particularly adapted for the production of light castings in iron molds, without the use of expansible cores, and to be especially suitable for various electrical and mechanical work, since a smooth finished casting may be obtained without machining.

Electric Steel Furnaces in Europe.

Stahl und Eisen of Oct. 7 contains a list of electric steel plants now in commercial operation.

Since we have noticed before in detail the industrial development in this country, we give in the following only a list of electric steel plants outside of the United States. We may mention, however, concerning this country that a Héroult furnace plant has been installed by the Firth-Sterling Steel Company at McKeesport, Pa., and that a Colby induction furnace is now in operation at Niagara Falls. We reserve further notes for a future issue.

HÉROULT FURNACE.

	Charge.	Power.
1. Richard Lindenberg, Remscheid, Germany.....	3,000 kg.	370 kw.
2. Richard Lindenberg, Remscheid, Germany.....	1,800 kg.	300 kw.
3. Bismarckhütte, Upper Silesia.....	3,000 kg.	400 kw.
4. Bismarckhütte, Upper Silesia.....	1,900 kg.	260 kw.
5. Deutsch-Oesterreichische Mannesmannröhren-Werke, Burbach.....	3,000 kg.	400 kw.
6. Dauner & Co., Judenburg, Austria.....	2,000 kg.	300 kw.
7. Gebr. Böhler & Cie., Kapfenberg, Austria.....	2,500 kg.	350 kw.
8. Gebr. Böhler & Cie., Kapfenberg, Austria.....	Not yet decided.	
9. Georg Fischer, Schaffhausen, Switzerland.....	1,000 kg.	250 kw.
10. Georg Fischer, Schaffhausen, Switzerland.....	5,000 kg.	...
11. Georg Fischer, Schaffhausen, Switzerland.....	5,000 kg.	...
12. Soc. Electromét. Française, La Praz, Savoy, France.....	3,000 kg.	370 kw.
13. Acieries du Saut du Tarn, St. Juéry, France.....	5,000 kg.	600 kw.
14. Aktiebolaget Héroults Elektriska Stål, Korfors, Sweden.....	4,500 kg.	300 kw.
15. Società Tubi Mannesmann, Dalmine, Italy.....	6,000 kg.	736 kw.
16. Società Tubi Mannesmann, Dalmine, Italy.....	6,000 kg.	736 kw.

Nos. 1, 2, 5, 6, 7 the charge is liquid steel, while furnaces No. 9, 10, 11, 12, 13, 15 and 16 are charged with cold material. Nos. 5, 8, 10, 11, 15, 16 are in course of erection; the others are in operation.

STASSANO.

	Charge.	Power.
1. Bonner Fräsefabrik, Bonn.....	1,000 kg.	185 kw.
2. Bonner Fräsefabrik, Bonn.....	1,000 kg.	...
3. Forni Termoelettrici Stassano, Turin, Italy.....	5,000 kg.	750 kw.
4. Forni Termoelettrici Stassano, Turin, Italy.....	5,000 kg.	750 kw.
5. Forni Termoelettrici Stassano, Turin, Italy.....	900 kg.	180 kw.
6. Forni Termoelettrici Stassano, Turin, Italy.....	900 kg.	180 kw.
7. Forni Termoelettrici Stassano, Turin, Italy.....	900 kg.	180 kw.
8. Forni Termoelettrici Stassano, Turin, Italy.....	400 kg.	75 kw.
9. Forni Termoelettrici Stassano, Turin, Italy.....	400 kg.	...
10. Government Arsenal, Turin, Italy.....	700 kg.	150 kw.
11. Government Arsenal, Turin, Italy.....	700 kg.	...

Nos. 2, 7, 11 are in course of erection; the others are in operation.

KELLER.

	Charge.	Power.
1. Holtzer & Co., Unieux, France (No exact data known).....

DU CIFFRE.

	Charge.	Power.
1. Soc. des Hauts-Fourneaux et Forges, Alleverd, France.....	3,200 kg.	500 kw.
2. Soc. des Hauts-Fourneaux et Forges, Alleverd, France.....	3,200 kg.	500 kw.

Nos. 1 and 2 are in operation.

GIROD.

	Charge.	Power.
1. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	1,800 kg.	300 kw.
2. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	2,000 kg.	300 kw.
3. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	2,000 kg.	300 kw.
4. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	8 to 10,000 kg.	1,200 kw.
5. S. A. Electrometallurg. Procédés P. Girod, Ugine, Savoy.....	8 to 10,000 kg.	1,200 kw.
6. Oehler & Co., Aarau, Switzerland.....	2,000 kg.	300 kw.
7. Joh. Cockerill Seraing, Belgium.....	3 to 4,000 kg.	450 kw.
8. A. Stortz, Stuttgart-Kornwestheim.....	2,000 kg.	300 kw.
9. Marrel Freres, Rive de Gier, France.....	Not yet decided.	
10. Ternitz Eisen- und Stahlwerke, Ternitz, Austria.....	Not yet decided.	

Nos. 1 and 6 are in operation, the others in course of erection.

KJELLIN.		
1. Röchling, Völklingen, Germany.....	8,500 kg.	750 kw.
2. Fried. Krupp, Essen, Germany.....	8,500 kg.	750 kw.
3. Oberschlesische Eisenindustrie, A. G., Gleiwitz, Germany.....	1,500 kg.	180 kw.
4. Poldihütte, Kladrno, Bohemia.....	4,000 kg.	440 kw.
5. J. Brauns' Söhne, Vöcklabruck, Austria.....	400 kg.	65 kw.
6. Allg. Kalziumkarbid-Genossenschaft, Gurtneilen, Switzerland.....	?	330 kw.
7. Vidua de Urigoitia e Hija, Araya, Spain.....	1,500 kg.	215 kw.
8. Alti Forni Gregorini, Loreve, Italy.....	1,500 kg.	330 kw.
9. Iron Works Domnarfvet, Gysinge, Sweden.....	1,500 kg.	175 kw.
10. Metallurgiska Aktiebolaget, Trolhattan, Sweden.....	2,000 kg.	300 kw.
11. Vickers, Sons & Maxim, Sheffield, England.....	550 kg.	150 kw.
12. Gröndal-Kjellin Co., Nine Elms Lane, London, England.....	100 kg.	60 kw.

All the Kjellin furnaces are single-phase furnaces. Nos. 1 and 6 are no longer in operation; Nos. 8 and 10 are in course of erection. The others are in operation.

RÖCHLING-RODENHAUSER.		
	Charge.	Power.
1. Röchling, Völklingen, Germany.....	3,500 kg.	400 kw.
2. Röchling, Völklingen, Germany.....	8,500 kg.	750 kw.
3. Röchling, Völklingen, Germany.....	2,000 kg.	275 kw.
4. Bergische Stahlindustrie, Remscheid, Germany.....	...	500 kw.
5. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	700 kg.	100 kw.
6. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	3,500 kg.	300 kw.
7. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	3,500 kg.	300 kw.
8. Le Gallais, Metz & Co., Dommeldingen, Luxemburg.....	1,500 kg.	275 kw.
9. Aciéries Liégoises, Bressoux-les-Liège, Belgium.....	1,000 kg.	200 kw.
10. J. Knöpfel, Walzenhausen, Switzerland.....	1,000 kg.	175 kw.

Nos. 1, 2, 4, 5, 6 and 7 are single-phase furnaces; Nos. 3, 8, 9 and 10, three-phase furnaces. Nos. 2, 6, 7, 8, 9, and 10 are in course of erection; the others are in operation.

SCHNEIDER.		
	Charge.	Power.
1. Schneider & Co., Creusot, France.....	1,000 kg.	...

SCHNEIDER-GIN.		
	Charge.	Power.
1. (?) Plettenberg, Westf. (in course of erection)	4,500 kg.	400 kw.

FRICK.		
	Charge.	Power.
1. Fried. Krupp, A. G.....	10,000 kg.	750 kw.
2. John Brown & Co., Sheffield, England.....	1,800 kg.	200 kw.
3. Wm. Jessop & Sons, Sheffield, England.....	3,000 kg.	450 kw.

Nos. 1 and 2 are in operation; No. 3 has been discontinued.

A. G. ELECTROMETALL, LUDVIKA.		
	Charge.	Power.
1. Arvika, Sweden.....	1,000 kg.	175 kw.
2. Hagfors, Sweden.....	500 kg.	125 kw.
3. St. John del Rey Mining Co., Brazil.....	2,000 kg.	300 kw.

No. 1 is in operation; Nos. 2 and 3 have been discontinued. All are three-phase furnaces. All the furnaces mentioned on this page are induction furnaces.

Electrochemistry at the Electrical Show.

The New York Electrical Show, held under the auspices of the large electric central station companies of Greater New York to commemorate the first quarter of a century of electric service in New York and fifty years of transatlantic communication by cable, was opened on Oct. 3, and during the ten days of its existence it attracted a very large attendance, especially during the closing days, although no free tickets had been given out this year.

The opening exercises on Oct. 3 were unique in so far as all the congratulatory and introductory speeches were made by phonograph. These seven speeches were made by Mr. Thomas A. Edison, president of the Show; Mr. Louis A. Ferguson, president of the American Institute of Electrical Engineers; Mr. William C. L. Eglin, president of the National Electric Light Association; Mr. W. W. Freeman, president of the Association of Edison Illuminating Companies; Mr. E. G. Acheson, president of the American Electrochemical Society; Mr. Henry A. Lardner, president of the New York Electrical Society, and Governor C. E. Hughes of New York State.

From Mr. Edison's speech we quote the following:

"The lesson of the jubilee of the Atlantic cable of 1858 is one of encouragement to all who would add to the resources

of our race and extend our control over the forces of nature. Never was failure more complete, never was higher courage shown, never was triumph more brilliant than that which since 1866 has kept the Old World moored alongside the New by pulsating cables of steel and copper—the 'family ties' of the civilized world.

"When I look around at the resources of the electrical field to-day as shown in this Exhibition, I feel that I would be glad to begin again my work as an electrician and inventor; and we veterans can only urge upon our successors, the younger followers of Franklin and of Kelvin, to realize the measure of their opportunities and to rise to the height of their responsibilities in this Day of Electricity."

Mr. Acheson's speech was as follows:

"Electrochemistry has furnished the fifth and latest important application of electricity, the other four being in the order of their development—telegraphy, telephony, lighting and traction. The Electrical Engineer and the Chemist having joined hands, we now have the new science—Electrochemistry, one devoted to the creation of new materials, and also the better and cheaper manufacture of others used in the world's industries.

"Electrochemistry, while one of the youngest of the sciences, has become one of the most important. National societies, devoted to its interests, already exist in the industrial countries of the world. Having made its appearance at Niagara Falls in 1895, it is now producing, at that center, aluminium, carborundum, carbide of calcium, caustic soda, bleaching powder, graphite, metallic sodium, metallic silicon, and other materials, the united value of their annual production amounting to several millions of dollars, and these are produced by the utilization of a very small fraction of the possible power of Niagara Falls.

"While the earlier applications of electricity have extended man's field of operation and increased his comfort, by the agency of electrochemistry, waste materials are being transformed into valuable products, thereby adding to the world's wealth and conserving our natural resources.

"I am pleased that this Exposition brings to notice some of the possibilities of this new and interesting science."

* * *

The New York Edison Company, the United Electric Light & Power Company and the Edison Electric Illuminating Company, of Brooklyn, as the organizers of the show, occupied large spaces, and the last two companies had arranged comprehensive, attractive and instructive exhibits.

The exhibit of the United Electric Light & Power Company was primarily intended to show the possibilities of alternating and polyphase currents. The exhibit of the Brooklyn Edison Company comprised three sections: a domestic section, showing the various uses of electricity in the kitchen and for numerous household appliances; a commercial section, illustrating the possibilities of electric illumination of haberdashery with show-window display; and a very instructive industrial section. In the latter a 25-hp gas engine, a 25-hp steam engine, and a 25-hp electric motor were shown side by side in operation. The arrangement brought out the points of superiority of electric driving in a very clever and forceful manner.

The most striking feature of the whole show was undoubtedly the brilliant illumination, and the most interesting feature of the illumination, from an engineering point of view, was the practical absence of the carbon lamp and the complete predominance of tungsten and other metallic-filament lamps, as well as of various types of new arc lamps with impregnated carbons. Very few of the thousands of visitors have probably thought of this feature in connection with electrochemistry. Yet it is, nevertheless, a fact that this revolutionary change in modern electric lighting methods is primarily the result of electrochemical and chemical research.

However, there was also a specific electrochemical exhibit of a comparatively small compass and by no means complete, yet interesting and instructive.

The chief corner of the electrochemical exposition was occupied by the **International Acheson Graphite Company** of Niagara Falls. Their exhibit, which was exceedingly attractive, had been arranged by Mr. E. G. Acheson himself and by Mr. W. Acheson Smith. It showed the enormous range of different industrial fields for which artificial graphite has become indispensable.

The now familiar applications of Acheson graphite for electrodes, dry-battery fillers, paint pigments, for electrotyping, lead pencils, rifle lubrication, gear, cup and ball-bearing lubrication were, of course, shown. Among newer applications was the use of artificial graphite for pyrometer tubes.

The ease of machining artificial graphite makes it enormously useful for many purposes. Thus, the method of screwing one large graphite electrode into another one (so as to obtain a continuous feed of electrode and avoid any interruption of electric furnace operation) was shown. That it is possible to do almost anything with artificial graphite was indicated by some tiny, delicate elastic spiral springs cut out of a graphite tube. Another pretty exhibit was a baked amorphous carbon electrode for batteries of very delicate construction, which had been artificially graphitized.

There were, of course, also exhibits of aquedag and oildag, i. e., deflocculated graphite suspended in water or oil (our Vol. V, page 452, which are now becoming important lubricants.

A small, but particularly interesting exhibit of Mr. Acheson were three reguli of aluminium, since they had been made by reduction of alumina with carbon in the electric furnace.

The exhibit of the **Norton Company**, of Worcester, Mass., occupied the next table. It had been arranged in an artistic manner by Mr. H. K. Dodge, New York manager of the Norton Company. As is well known, this company makes alundum, i. e., artificial emery, by fusion of bauxite in electric furnaces in their Niagara Falls works.

Their exhibit included samples of natural bauxite and of regular, white and blue-black alundum. There were also 13 bottles, containing alundum in grains, showing the various sizes used in the manufacture of grinding wheels. As finished products were shown seven small grinding wheels of different kinds made of alundum, five specimens of rubbing and sharpening stones made of alundum, and two sheets of alundum cloth. The manufacture of artificial emery in the electric furnace has, indeed, undergone a very interesting and successful development during the last seven years under the care of the Norton Co.

The **Aluminum Company of America** of Pittsburgh had a fine exhibit. As is well known, this company is the sole producer of aluminium in this country, using the process of Mr. Charles M. Hall. Through his kindness and that of the chief chemist of the company, Mr. E. Blough, this exhibit had been procured. It was well representative of the smaller-sized commercial articles manufactured from aluminium at present.

The exhibit of aluminium castings included pipe fittings, meter frames and covers, etc. Aluminium tubing, samples of which were shown, should be especially interesting to our readers, since it is coming into wide use in the chemical industries, especially for acetic acid manufacture, nitric acid condensers, sulphide pulp mills, ammonia concentrators, etc. Aluminium cables were exhibited bare, insulated and lead-covered. The McIntire joint was shown. Quite interesting were bimetallic wire with a steel core and an envelope of aluminium and bimetallic tubing, containing aluminium inside and copper outside. Various aluminium shapes were shown for use on automobiles, trolley shoes, etc.

An apparently new industrial development is the drawing and spinning of aluminium. It can be drawn into forms with few operations and little annealing, yet when of proper temper or suitably alloyed a very stiff finished product is obtained. Perhaps most interesting to the general public was an exhibit showing the evolution of an aluminium coffee pot from blank plate to finished product in five operations.

Right next to the aluminium exhibit was that of the **Gold-**

schmidt Thermit Company of New York City, which had been kindly placed at the disposal of the show by Mr. E. Stütz, vice-president and general manager of the company, and had been arranged by the manager of their sales department, Mr. W. H. Hulbert. Samples of the following metals, free from carbon and made by the aluminothermic process, were exhibited: chromium, manganese, molybdenum, manganese-copper, manganese-zinc, manganese-tin, ferrovanadium, ferrotitanium and ferroboron.

There were also shown samples of ordinary black thermit, nickel thermit and manganese thermit and a can of ignition powder. A tripod and automatic crucible, ready for a weld, were also exhibited, as well as finished pipe welds and a sample of the compromise rail weld. In addition, there were four photographs showing a number of large thermit welding operations, carried out in practice.

The **Castner Electrolytic Alkali Company** of Niagara Falls, through the kindness of their general manager, Mr. Max Mauran, exhibited samples of their caustic soda and bleaching powder. One sample of the caustic soda was crystalline, showing the long grain and lustrous fiber peculiar to the high-strength caustic made by the Castner mercury-cathode process. The other sample showed caustic molded in form of sticks for laboratory use. This caustic is 99.5 per cent pure. The bleaching powder tests 37½ per cent available chlorine.

The **Union Carbide Company** and the **Electro Metallurgical Company** of New York City, through the courtesy of their general manager, Mr. E. F. Price, and of the chief metallurgist of the latter company, Mr. Fred. M. Becket, exhibited three jars of calcium carbide and three lumps of ferrochromium, ferrosilicon and ferrovanadium low in carbon.

The **American Cyanamide Company** of Nashville, Tenn., exhibited a sample of calcium cyanamide, made from calcium carbide. The company has made some improvements in the product they propose manufacturing, as compared with the product manufactured in Europe. In deference to the requirements of the fertilizer trade, they have reduced the content of ammonia, and have also converted the free lime present in cyanamide into land-plaster. They are now erecting a plant in Niagara Falls. We intend to give further notes on this interesting development in the near future.

The **Carborundum Company** of Niagara Falls, through the kindness of their works manager, Mr. F. J. Tone, exhibited a beautiful lump of carborundum crystals and a large sample of metallic silicon, made in the electric furnace.

The **United States Metals Refining Company** of Chrome, N. J., through the courtesy of their superintendent, Mr. Lawrence Addicks, exhibited a series of very interesting samples showing the different stages of the metallurgy of copper from ore to insulated copper wire. There were samples of copper sulphide and copper carbonate ores, copper matte, anode copper and cathode copper, etc., and samples illustrating the evolution of insulated wire from wire bar.

The **Hoskins Company** of Chicago had an exhibit of various small electric furnaces, which was particularly interesting, since their Eastern manager, Mr. M. M. Kohn, 205 Postal Telegraph Building, New York City, was present every night and showed the furnaces in operation to an always large and interested attendance. The furnaces exhibited were an electric combustion tube furnace (particularly suitable for rapid determination of the carbon content of steel by the direct method), an electric muffle furnace (useful for all purposes for which the muffle is adapted, and, in addition, for steel manipulation for optical works, for baking and enameling porcelain, etc.), and a combination furnace which can be used as a crucible furnace or muffle furnace.

There was also a very interesting historical exhibit, contributed by Dr. Chas. A. Doremus and relating to the work of Joseph Henry, Robert Hare, Moissan and Berthelot.

An account of other exhibits at the Show will be found on page 475.

Grinding Mill with Air Separation.

As the grinding, pulverizing and separating machinery of the Raymond Brothers' Impact Pulverizer Company, of Chicago, has been briefly noticed before repeatedly in our columns, the following more detailed description of their mills, with some results obtained recently in commercial practice, should be interesting to engineers in those numerous chemical and metallurgical industries in which fine grinding and great uniformity of the ground product are matters of prime importance.

The Raymond Brothers' Impact Pulverizer Company has specialized for a great many years in fine grinding, meaning 70 mesh and finer down to 200 mesh and impalpable powder. A single one of their special fields is the lime grinding industry in the large beet sugar plants all over this country, where the lime is ground so that between 99 and 100 per cent passes a 200-mesh test sieve. But similar results are desired or required also in a great many chemical industries.

The fundamental feature of the Raymond system is the



FIG. 1.—GRINDING MILL WITH AIR SEPARATION.

principle of air separation. It is an exceedingly simple principle, based on the fact known from every-day life, that a current of air passing over fine particles of material in form of dust or the like will carry these particles along, and that with an increase in the speed of the air current proportionally heavier particles will be picked up.

Fig. 1 shows the typical Raymond roller-mill plant. *A* is the foundation of concrete, timber, or simply a good, strong floor. *B* is the roller mill. *C* is the vacuum separator, which varies in size from 6 to 16 ft. in diameter; the finer the product required, the larger is the separator.

D is the exhaust fan. (As shown in Fig. 2, it can be set so as to exhaust from top of separator.) *E* is the galvanized-steel dust collector and settling chamber, which can be set higher so as to discharge into a storage bin if desired. *F* is the return air pipe. *G* is the galvanized-steel housing around the mill, to conduct the return air into the pulverizing chamber.

H is the vent pipe, to relieve back pressure or to relieve the system from any surplus air that might enter with the feed or any opening provided to admit air from the outside. This pipe usually leads to a small dust room or any suitable dust collector.

M (at the bottom of the settling chamber *E*) is the discharge spout for the finished product.

The roller mill crushes and grinds the material by gravity and centrifugal force. A plow is located ahead of each roller and constantly throws a stream of material between the face of the roller and the ring die.

In the mills with air separation, the air enters the mill through a series of tangential openings around the pulverizing chamber directly under the ring die and rollers, and that portion of the material which is reduced to the required fineness by the rollers passing over it once is instantly carried away by the air current, but that which is not fine enough drops down, is caught by the next plow following and carried between the succeeding roller and the ring die, to receive like treatment. If the mill is kept properly filled with material, each of the plows will throw

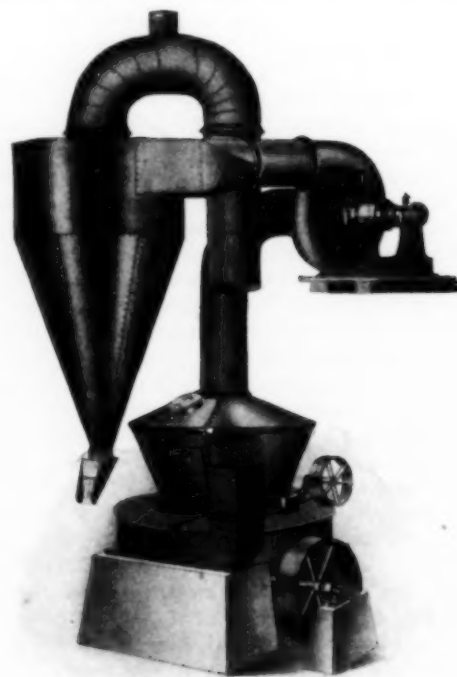


FIG. 2.—ROLLER MILL WITH AIR SEPARATION.

a constant stream between the two grinding faces, preventing direct contact of roller and ring die.

An interesting feature of the construction is that the casting supporting the plows is attached to the slow speed upright shaft, and very little power is required to raise the material and throw it between the crushing surfaces of the roller tire and the ring die.

The plows can be removed or adjusted by simply opening one of the doors and without taking the machine apart, and the construction of the mill permits the face of the rollers to remain always parallel with the face of the ring die.

Fig. 2 shows the latest form of the Raymond standard four-roller mill, with the rollers suspended and the pneumatic separator with a revolving disk taking the place of the inner cone in the standard separators. The suspended roller mill has been on the market so long that its merits are known to all engineers. The only difficulty heretofore has been that the mill was surrounded by a screen, through which the material had to pass, and when a fine finished product was desired it became necessary to use a fine mesh screen or bolt the material outside the mill, returning the tailings. The expense and trouble of bolters

are well known, and a sufficiently fine screen in the mill would on most materials clog, or at least so greatly reduce the mill's capacity as to lessen its economy. By attaching the air separator and admitting the air to the mill underneath the grinding surface, the material is taken away by the air current, as fast, and faster than it is reduced; the separator returning the coarse material to the mill in a continuous stream, from the edge of the revolving disk, over which a thin sheet of air at high velocity is constantly passing, separating the fine powder. These features give the mill very high capacity, and at the same time insure a finished product of uniform fineness.

One of these four-roller mills has just been installed in the works of the Pennsylvania Cement Company at Nazareth, Pa. This mill requires only from 65 to 70 hp and grinds $6\frac{1}{2}$ tons per hour, 97½ per cent passing through a 100 mesh and 92 per cent through a 200 mesh. The large proportion of the 200-mesh product or fine powder is remarkable. The mill is fed with material crushed only to 1 in., some of it to $1\frac{1}{2}$ to 2 in. in size.

Last winter the Raymond company installed nine mills in the raw grinding department and three mills in the coal grinding department of the new Huron Portland Cement Company's plant at Alpena, Mich. The following figures are taken from the daily reports of the first six days in September:

	Raw material.	Coal.
Sept. 1	98.4%	98.4% passed 100 mesh
Sept. 2	98.2%	98.4%
Sept. 3	98.5%	98.5%
Sept. 4	98.4%	98.5%
Sept. 5	98.4%	98.6%
Sept. 6	98.6%	98.6%

These figures show the great uniformity of fineness of the product obtained from day to day. It is stated that these results have been the same every day since the mills were started last spring.

A New Chemical Stoneware Factory.

The works of the Didier-March Company, which were recently finished, are located on the Raritan River at Keasby, near Perth Amboy, N. J., and are readily accessible both by water and rail, permitting of economical and rapid delivery under all conditions.

The mines, furnishing an extensive variety of domestic clay, are located in the immediate neighborhood of the factory buildings, thus enabling the raw materials to be handled at minimum

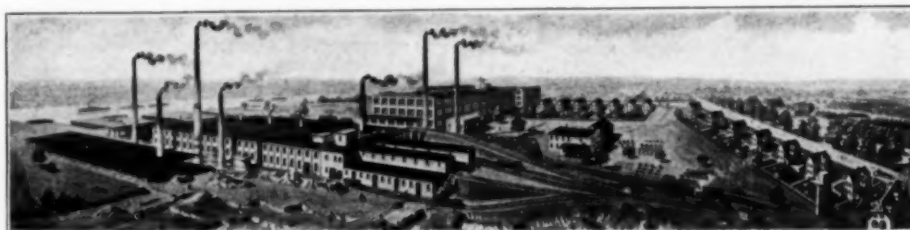
Experiments are continually being made to find combinations of raw materials superior to any heretofore discovered. In many cases in the manufacture of both acid-proof and highly refractory products specific requirements prohibit the introduction of domestic clay. For these cases use is made of an extensive stock of raw material obtained from the special clay deposits of Germany and Sweden. It is thus possible to make articles in every particular equal to those manufactured abroad, without the almost prohibitive expense and loss of time unavoidably attached thereto. Intimate connection between the Didier-March Company and the Deutsche Ton & Steinzeug Werke, and also the Stettiner Chamotte Fabrik A.-G., insures a ready adaptation of the latest European inventions and processes to American conditions.

The building used for the manufacture of chemical and electrolytic pottery ware is a thoroughly modern steel and concrete structure designed especially for the purpose, and absolutely fireproof. Machinery of the most modern and efficient type has been imported from abroad and represents the result of years of practical experience. As far as possible, manual labor has been supplanted by machinery, resulting not only in a considerable decrease in the cost of production, but also in a more uniform product. With a view of minimizing the actual operating expenses, entirely mechanical conveying appliances are used for transporting the raw material, both before and after the process of preparation, as well as the finished products.

In order to allow of manufacturing the latest and most intricate apparatus for the chemical industry, an extensive model room is provided, equipped with the most modern appliances.

Ample kiln capacity is provided, thereby insuring rapid deliveries of the great variety of articles manufactured. In order to obtain the maximum economy in the process of burning, a modern type of square down-draft kilns has been erected, which embody all the improvements made during years in the largest plants of Europe.

Besides manufacturing the many apparatus regularly required in the chemical industries, as noticed in the catalog of the Didier-March Company, apparatus of special and intricate form can be executed at short notice. Among these may be mentioned all the necessary apparatus required in the manufacture of sulphuric and sulphurous acids; hydrochloric and nitric acids; explosives (after the system of Griesheim, Guttman, Valentiner, Uebel, Thomson and others); chlorine; bromine; iodine; formaldehyde; acetic acid, etc.; also complete denitration and regeneration plants, constructed according to patented



WORKS OF THE DIDIER-MARCH COMPANY IN KEASBY, N. J.

cost. For the accommodation of the employees of both the refractory clay and pottery departments, a number of cottages are provided. This promotes a considerably greater interest of the employees in their daily work than would otherwise be the case.

In order that the manufacture of both the pottery and refractory clay products may be carried on along strictly scientific lines, an extensive chemical and physical laboratory has been established under the supervision of a trained chemical engineer, which makes it possible to scientifically determine the requirements of the many special uses to which clay products are now subjected.

processes, for which the Deutsche Ton & Steinzeug Werke, of Charlottenburg-Berlin, Germany, and the Didier-March Company are the exclusive makers of the stoneware parts.

Ore Concentration.—The National Ore Concentration Company, of Chicago, have sent us their bulletin on the Woodbury system of ore concentration. In this the "preliminary separation," by means of classifiers, screens, etc., is largely eliminated, the classifying and jigging operations being combined into one. A new plunger jig has been developed from the older types of jigs, of greatly increased capacity and capable of treating unclassified ores.

Reversion Recorder for Regenerative Furnaces and Coke Ovens.

The progress which has been made in recent years in the methods employed by the steel industry is well illustrated by the extensive use of exact measuring instruments, like pyrometers, and by the further tendency of employing recording rather than indicating instruments.

A recording instrument furnishes at once a full and permanent record of the operation. A comparison of the charts obtained every day reveals immediately any irregularities, which may then be at once investigated. At the same time the chart serves as an admirable timekeeper; the furnace man is permanently under the control of the recording instrument.

A new development along this line is the Sarco Reversion Recorder for regenerative furnaces and coke ovens, made by the Sarco Fuel Saving & Engineering Company, West Street Building, New York City. This instrument, constructed on strictly scientific principles, produces a permanent record of each reversion of the gas valves on regenerative furnaces, the

The chart on which the record is plotted is divided by a center zero line, and the pressure existing in the flue at the time gas is passed through is recorded by a horizontal line below zero. At the moment of reversing, the pen will rise above the zero line and register the suction then created by the draught from the chimney.

Thus not only the gas and air pressures are measured, but a diagram is produced which shows, at a glance, whether the valves have been reversed regularly and at the proper time.

Laboratory-Rheostat.

The Ward Leonard Electric Co., of Bronxville, N. Y., has just placed upon the market a laboratory rheostat of large capacity, which is at the same time fool-proof. It is shown in the adjoining illustration.

There has long been a demand for a rheostat which may be

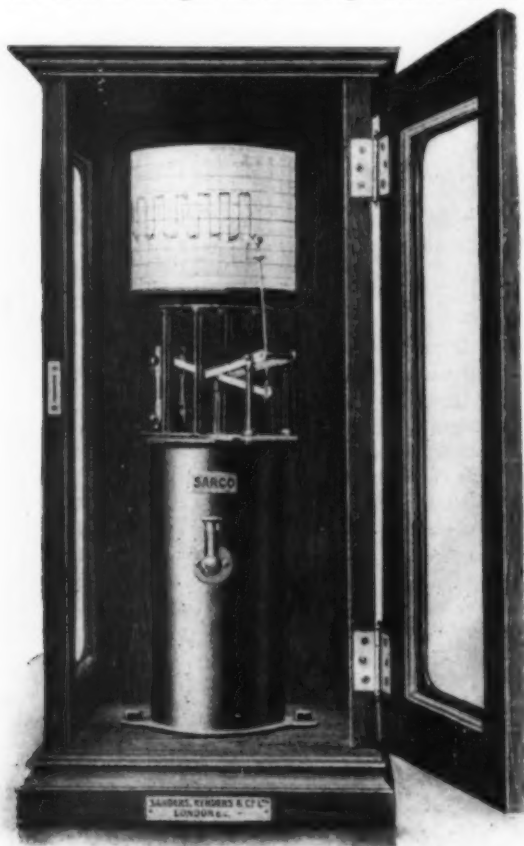


FIG. 1.—REVERSION RECORDER.

exact time when it takes place and, further, the draught and gas pressures at the time.

The construction is as follows: The cylindrical body of the instrument contains a bell, floating in glycerine. The air space above this bell is kept under atmospheric pressure by means of a small opening in the instrument; a tube enters from below and extends above the level of the glycerine into the air space under the bell, which is otherwise sealed. This tube is connected to a pipe, tapping one of the gas flues between the regenerator and the reversing valve, and thus any variation in the pressure in the same will cause the bell to rise or fall, as the case may be. This motion is transmitted to a pen by means of a small rod, as shown in the illustration, and a very sensitive parallel gear, and the pen in its turn registers the changes in the pressure on a continuous chart placed on a drum fitted with a clockwork.



RHEOSTAT.

connected directly to the supply voltage and by means of which it is possible to get any desired amperage. The Ward Leonard rheostat is designed for a maximum current of 56 amp, and the current may be adjusted in steps of 0.1 amp from 0.1 to 56 amp. The rheostat can be used both on direct-current or alternating-current circuits. It has a non-inductive resistor with practically zero temperature-coefficient of resistance.

The system of the connections is exceedingly simple. Each resistor with its controlling switch is designed to be connected across the full line volts. Each switch is marked with the number of amperes that will flow when it alone is closed. Any desired reading can be obtained by closing the proper switch or switches. As each resistor is designed to carry the full line volts, "burn-outs" are impossible, and overload protective devices for preventing accidents to the rheostat are unnecessary.

The resistor portion is 10 in. x 12 in. x 15 in. over all. It can be mounted on the side wall out of the way. The face plate or controlling portion is only 14 in. x 8 in. It can be mounted on the test table, inside the cover of the desk, etc. Unless otherwise specified, however, the complete rheostat is furnished as shown in the illustration.

The resistor elements are built up of Ward Leonard enameled resistor units, millions of which are in service. They are fire-proof, strong, of light weight, and are thoroughly protected against injury from mechanical, electrical and chemical causes. It is stated that this is the first "fool-proof," heavy-duty

rheostat that has ever been placed upon the market for laboratory service, giving very fine gradations for control of the current.

Some Exhibits at the New York Electrical Show.

On pages 470 and 471 of this issue a full account is given of the special electrochemical exhibit at the recent Electrical Show in Madison Square Garden. In the following we give notes on some other exhibits which should be particularly interesting to chemical and metallurgical engineers.

The **Goulds Manufacturing Company**, of Seneca Falls, N. Y., had an interesting exhibit of triplex pumps, in charge of Mr. William H. Kemp. The different methods of driving pumps by electric motors, either by direct connection or by belt connection or through reduction and worm gearing, were shown. Of special interest was a working exhibit of a pump lifting water into a tank fitted with a float switch, thus showing the automatic feature of the set. While the pumps exhibited were for ordinary use, it is interesting to note that the Goulds Manufacturing Company also make a specialty of pumps for chemical and metallurgical purposes. For instance, the plant of the Solvay Process Company is equipped with special forms of Goulds triplex power pumps, specially designed and built for handling three different chemical solutions at the same time, saving space and power.

Another pump exhibit was that of the **Watson-Stillman Company**, of New York, in charge of Messrs. Edward Johnson, James Hargan, and Harry Printel. This company showed six electrically-driven pumps, differing in size, and also hydraulic jacks and shaft straighteners in operation. They also build special pumps for chemical and metallurgical work.

The **Heany Fireproof Wire Company**, of York, Pa., exhibited their asbestos-covered wire which should be of great advantage wherever an electric wire is subjected to a high temperature, which would be dangerous in case ordinary wire were used. This fact makes the asbestos wire especially applicable in close proximity to furnaces, etc., but also in such cases where there is liability of heavy overloads producing excessive heat inside the wires. An interesting little piece of the exhibit which was in charge of Mr. W. A. Ernst, was an asbestos-covered wire in which the inner copper conductor had been caused to melt by a heavy electric excess current, without destroying the surrounding asbestos envelop.

The pure asbestos is applied to the wire by a special process of Mr. Heany and the only foreign material used in this insulation is the inorganic fireproof and waterproof compound by which the asbestos is cemented to the wire. The wire has been found to be able to withstand 100 per cent overload in heavy street railway machinery. Since similar severe conditions as in traction are experienced in the power supply of steel mills and in metallurgical works in general, the asbestos-covered wire should prove of service for such work. It is self-evident that it should be particularly useful for such special cases as the magnet windings of induction furnaces.

The **Driver-Harris Wire Company**, of Harrison, N. J., had an interesting exhibit of their special resistance wires, in charge of Mr. A. Benschel. The special feature was a sign, made of their "nichrome" wire which although continually heated by electric current to red heat, was shown not to oxidize. Nichrome is an alloy of nickel and chromium; its characteristic features are the ability to withstand high temperatures up to 1500° F. without oxidation, and the facts that it is practically non-corrosive and will not become brittle with repeated heating and cooling. Its specific resistance is 575 ohms per milfoot, with a temperature coefficient of 0.00024 per degree F. It is furnished either in ribbon or wire form and should prove very useful as resistor for certain types of resistance furnaces.

Another special resistance alloy of the Driver-Harris Company is "climax" (a special nickel steel), which has a resistance 50 times that of copper. Unlike German silver, climax

does not become brittle with repeated heating and cooling.

Still another special alloy of this company is "advance," a copper nickel alloy, containing no zinc. Its specific resistance is 28 times that of copper and its temperature coefficient is practically nil. It does not become brittle with repeated heating and cooling and is non-corrosive. This alloy is chiefly used in measuring instruments, resistance units, motor starters, etc.

The company's complete line includes many special alloys. Among those exhibited were manganine, German silver, and ferro-nickel.

The **Habirshaw Wire Company**, of Yonkers, N. Y., had a large and fine exhibit of wires and cables for various voltages and amperages. While the feature of the exhibit was a sample of the largest telephone cable built for submarine purposes, there were also shown numerous samples of cables for power transmission, including the cable used at Niagara Falls. The exhibit was in charge of Mr. James B. Olson and Mr. Carl F. Obermaier.

The **Murphy Electricity Rectifier Co.**, of Rochester, N. Y., exhibited a new machine for charging alternating into direct current. This should be useful for all cases where direct current is needed for electrolytic work, for instance, for electroplating, for charging storage batteries, etc., while only alternating current is available from the town-supply circuits. The usual methods employed now in such cases, are to install either a motor-generator or rotary converter or a rectifier either of the electrolytic type with aluminium electrodes or of the mercury-vapor tube type. The new apparatus, exhibited by Mr. T. J. Murphy, who was himself in charge of the exhibit, may perhaps be called a mechanical rectifier, since the rectifying effect is obtained mechanically by a special commutator. This is driven by a small synchronous motor. It is expected that the apparatus will soon be placed on the market.

The **General Electric Co.**, of Schenectady, had a very fine exhibit, showing its multifarious interests. Among the representatives present were Mr. F. H. Gale, Mr. W. C. Andrews, and many others. The features of their exhibit was the tungsten lamp and their electric heating apparatus. A 35-kw Curtis turbine set was also exhibited.

The exhibit of the **Electrical Testing Laboratories**, of New York City, had various instructive and even spectacular features, including an insulator-testing plant in operation. The test current was supplied from a 250,000-volt transformer. The spherical photometer, which enables the determination of the candle-power of a lamp by a single measurement, was shown with the Sharp-Millar photometer. The essential differences between the carbon arc, the magnetite arc, and the flaming arc, were nicely shown by projecting them side by side on a screen. The exhibit was in charge of Mr. McDonald.

Zaremba Company.

Mr. Edward Zaremba, formerly manager of the American Foundry & Machinery Company, builders of the Swenson evaporator, has organized the Zaremba Company to build evaporators of the new Round-Body Type and also other styles of single and multiple effects. Besides evaporators it will furnish vacuum dryers, diffusion and leaching batteries and various types of chemical machinery.

The engineer of the new concern, Mr. Otto Mantius, has had a wide experience in the above lines in Germany, France and Belgium.

It will be the policy of the Zaremba Company to treat every proposition strictly with reference to the customer's conditions, building in each case the most suitable form of apparatus.

The headquarters will be at the Monadnock, Chicago.

Obituary.

We regret to report the death of Mr. George G. Blackwell, senior member of George G. Blackwell, Sons & Company, Ltd., in Liverpool, England, on Aug. 26.

Digest of U. S. Patents.

Compiled by Byrnes, Townsend & Brickenstein, Patent Lawyers, National Union Building, Washington, D. C.
ELECTRIC FURNACES (Continued).

571,655, November 17, 1896, Adam Charles Girard and Ernest Auguste Georges Street, of Paris, France.

Arc type. The furnace chamber is a vertical carbon tube, having at its top a hopper with sealed cover, and surrounded by a refractory block encased with metal. Horizontal carbon electrodes extend through side openings nearly to the tube. An arc is sprung from one electrode to the tube and thence to the other electrode. Gas may be supplied through an opening at the top, or through holes in the electrodes. The product is discharged from the lower end of the carbon tube or through a lateral taphole. Also illustrates a furnace in which the carbon tube passes through alined openings in the ends of parallel carbon plate-electrodes, the arcs being magnetically rotated as in patent No. 555,626.

572,312, December 1, 1896, Edgar F. Price, of Newark, N. J.

Arc type. The furnace is a tilting structure having an open top and end, through which the molten product is discharged into a receptacle clamped against the bottom of the furnace. The hearth and three sides of the smelting chamber are carbon slabs, the sides having outer walls. A hopper is supported on the upper edge. Five vertical, independently-adjustable carbon electrodes are arranged in a longitudinal series, arcing to the carbon hearth. Each electrode is surrounded, near its middle, by a water-cooled case. The charge-mixture gravitates downward between the electrodes and cases. The spaces between the cases open into flues leading to a condenser and stack.

573,041, December 15, 1896, Martin Schindler, of Neuhausen, Switzerland.

The furnace is a pot having a carbon hearth-electrode receiving a depending carbon electrode. This electrode may be square or circular in cross-section. The square electrode has a holder and terminal consisting of two parts having half-seats and bolted together. The holder for the circular electrode is annular and has a downwardly-extending flange. Tortuous or spiral cooling-passages are provided in the holders, through which cold atmospheric air is circulated. The carbon hearth may also be secured in a metal base having cooling passages.

575,115, January 12, 1897, Alfred E. Hunt, of Pittsburg, Pa.

Resistance type. Heats a cast-iron mold, serving as a resistor, in order to produce sound castings of intricate shape, especially of aluminum. The mold has two annular contact pieces, one fixed to its upper end and the other vertically adjustable. The mold rests on a plate of asbestos. Before casting, the mold is heated by passing a current of electricity through it. After the metal is poured, the lower contact is slowly moved upward and a water or air blast is applied to the base of the mold, so that the metal cools progressively from the bottom to the top.

NEW BOOKS.

THE MINERAL INDUSTRY. Vol. XVI for 1907. 1127 pages, illustrated. Bound in cloth. \$10. New York: Hill Publishing Co.

COAL; ITS OCCURRENCE, VALUE, AND METHODS OF BORING. By R. Redmayne. 215 pages, illustrated. (Modern Practice in Mining.) Bound in cloth. Price, \$2 net. New York: Longmans, Green & Co.

A TEXT BOOK OF EXPERIMENTAL CHEMISTRY. By Edwin Lee. (For students of general inorganic chemistry.) 433 pages, 57 illustrations. Bound in cloth. Price, \$1.50 net. Philadelphia: P. Blakiston's Son & Co.

A TEXT BOOK OF PHYSICS. By A. Wilmer Duff, Karl E. Guthe, William Hallock, E. Percival Lewis, Arthur W. Goodspeed, Albert P. Carman, and R. K. McClung. 680 pages, 511

illustrations. Bound in cloth. Price, \$2.75. Philadelphia: P. Blakiston's Son & Co.

ELEMENTS OF PHYSICS. By G. Arthur Hoadley. 467 pages, illustrated. Bound in cloth. Price, \$1.20. New York: American Book Co.

ELECTRIC LIGHTING AND POWER DISTRIBUTION. By W. Perren Maycock. (An elementary manual of electrical engineering.) 619 pages, illustrated. Bound in cloth. Price, \$1.90 net. New York: Macmillan Co.

POCKET BOOK OF ELECTRIC HEATING AND LIGHTING. By Sidney Ferris Walker. (Comprising formulæ, tables, rules and data.) 416 pages, illustrated. Leather binding. Price, \$3. New York: Norman W. Henley Publishing Co.

PUBLIC WATER SUPPLIES. By E. Eugene Turneure and Russell Harry Luman. (Requirements, resources, and the construction of works; with a chapter on pumping-machinery.) By D. W. Mead. 825 pages, illustrated. Bound in cloth. Price, \$5. New York: John Wiley & Sons.

HINTS FOR CRYSTAL DRAWING. By Margaret Reeks. With a preface by J. W. Evans. With illustrations by the author. 168 pages. Bound in cloth. Price, \$1.10 net. New York: Longmans, Green & Co.

COLOR PHOTOGRAPHY, AND OTHER RECENT DEVELOPMENTS OF THE ART OF THE CAMERA. By C. Holme. 123 pages, over 100 illustrations. Paper binding. Price, \$3 net. New York: John Lane Co.

THE GEOLOGY OF COAL AND COAL-MINING. By Walcot Gibson. (Arnold's geological series; general ed. J. E. Marr.) 351 pages, illustrated. Bound in cloth. Price, \$2.50. New York: Longmans, Green & Co.

THE WIMSHURST MACHINE: HOW TO MAKE AND USE IT. By Alfred W. Marshall. 112 pages, illustrated, 12mo. Paper binding. 25 cents. New York: Spon & Chamberlain.

MOTOR REPAIRING FOR AMATEURS. By J. H. Knight. 104 pages, illustrated. Bound in cloth. Price, \$1 net. New York: Spon & Chamberlain.

BOOK REVIEW.

METALLURGY: A CONDENSED TREATISE. Henry Wysor, Assistant Professor of Analytical Chemistry and Metallurgy in Lafayette College. 8vo.; 308 pages; 88 illustrations. Price, \$3.00. Easton, Pa.: The Chemical Publishing Company.

There was a need for just such a brief presentation of the art of extracting metals from their ores, for the use of college students beginning the subject and for the general public. There were, before this, books professing to answer these purposes, but they were mostly written by specialists, who gave prominence in them to this or that branch of the metallurgical art, at the expense of other divisions of the subject, and thus produced poorly balanced treatises. The chief merit of Mr. Wysor's book is its good balance, its equal treatment of all parts of the subject.

Without enumerating all the chapters, we may say that the work discusses the following topics: Physical properties of the metals, alloys, welding, plating, refractory materials and fluxes, theory of combustion, measurement of temperatures, natural fuels, artificial fuels, ore dressing, furnaces, metallurgy of iron and steel, copper, lead, zinc, tin, mercury, silver, gold, nickel, aluminium, manganese, chromium, tungsten, molybdenum, vanadium and platinum.

With all this condensed into three hundred pages, the treatment of each topic is necessarily brief, but it is very well condensed. The choice of the most important facts to present is excellent, and, although there are a few slips as to facts, yet the whole is so generally accurate and reliable that one would look in vain for a more satisfactory work on the subject condensed into such small compass.